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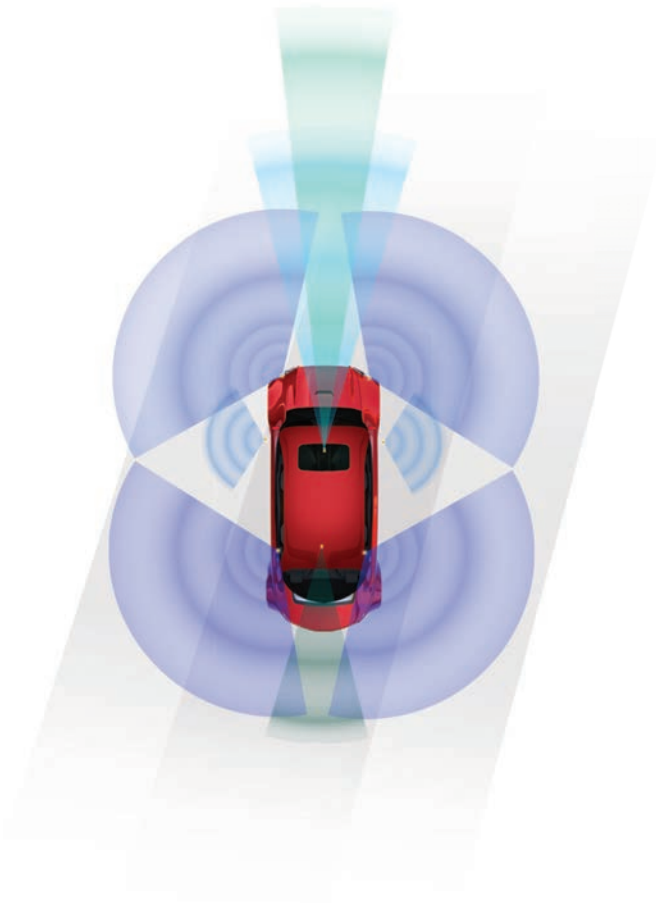

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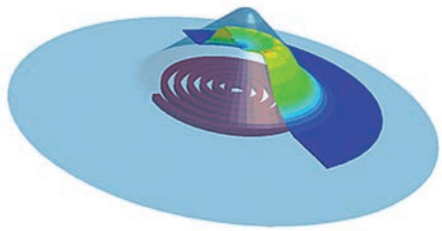
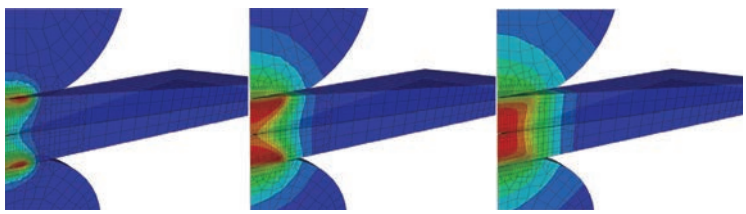
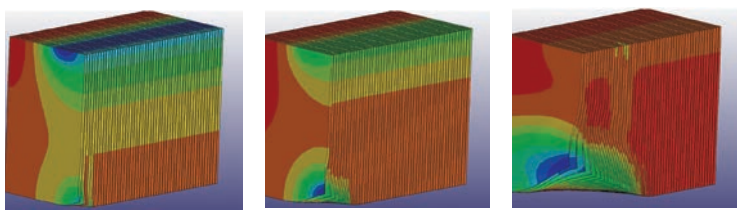


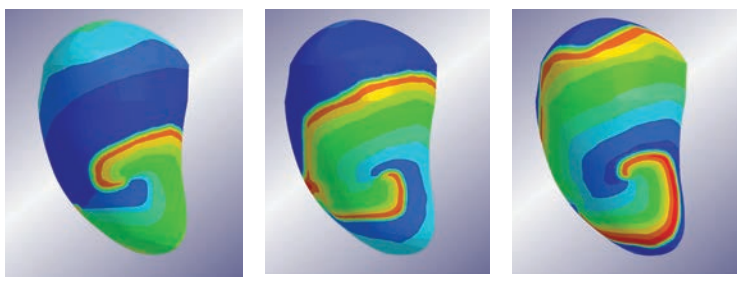
Magnetic forming of a metallic plate against a conical die.



Hot nugget development in a resistance spot welding simulation.



Evolution of the potential during the crush of a pack of 50 Li-ion cells.



Formation of a spiral wave in a ventricle during fibrillation.

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by Jamie J. Gooch

A Fond Farewell

IT HAS BEEN noted and quoted that the only constant in life (or engineering) is change. Design engineering teams are certainly familiar with this notion. From engineering change orders to change management processes that deal with digital disruption and transformation, change is often associated with a short-term loss and a long-term gain.

However, the long-term gains are never guaranteed. The future is fuzzy and—though you do your research and plan accordingly—determining when to take the leap often comes down to an imprecise "gut feeling." When it comes to discovering and implementing new engineering technologies, I hope *Digital Engineering* is part of that research. Whether it's the extended reality we focus on in this issue, a product lifecycle management upgrade or an additive manufacturing initiative, we strive not to just show you the latest technologies, services and processes, but give you insights on how they could affect design engineering in the long run.

Constant Change

DE has been faithful to its mission for almost 25 years now, and I have been privileged to be part of it for more than a decade. I've witnessed many changes in my tenure: cloud computing for engineering applications was scoffed at by some people we interviewed back then; the possibility of 3D printing metal parts at scale seemed like a fantasy and the democratization of simulation received the "nice idea, but it'll never work" reception.

When it comes to engineering technology, I've always approached such pessimistic viewpoints with a "wait-and-see" attitude. After all, I've ridden in a self-driving car, sent an issue of the magazine to the printer featuring the Mars rover on the cover weeks before the lander survived its "seven seconds of terror," and virtually poked my head into a combustion engine to take a look around. More importantly, I've met you—the design engineering community—and I know what you're capable of doing. You're a skeptical bunch when it comes to new technology, and often rightly so. But you're fueled by challenges and are always looking for a better, faster, cheaper way to design and develop products that can make the world a better place.

Collaboration and Inspiration

This will be my last issue of *DE*. I've been blessed with a great work environment and great co-workers, but my gut tells me it's time for a change. Eleven years is a long time, and I'm ready to take on a new challenge. I'll remain in the industry, working with a software vendor on its publications, so I won't be going too far afield.

What I'm not looking forward to is leaving my *DE* team. They are an extremely talented and hard-working crew. They're always looking for a better way to provide the information you need, when and where you need it. You can see that in the DigitalEngineering247.com website we redesigned last year. We made it easier to find information, and it responds to whatever size screen you're using. You also see it in the mobile-friendly digital editions and interactive special issues we produce, and in the webcasts, videos, magazines and research reports we create.

Focus on the Future

This fall, *DE* will launch its first virtual conference, continuing the momentum from our Conference on Advancing Analysis & Simulation in Engineering (CAASE) that we partnered with NAFEMS on last year. CAASE20 planning is already well underway for the next physical conference, which will take place June 16-18 in Indianapolis, and there are many more exciting initiatives in the pipeline for next year as well.

I'll miss being involved in those new initiatives, but will still turn to *DE* for the latest news, trends and insights on design engineering technology. I look forward to seeing what changes the design engineering community tackles next. I hope my tenure here has played a part in providing you with useful information that has helped you in your work. I am extremely proud of what my colleagues and I have done over the years, and anticipate great things for *DE* in the future. Thanks for reading *DE*. DE

Jamie Gooch *is editorial director of* Digital Engineering. *Contact him via jgooch@digitaleng.news.*

DE Digital Engineering

DE EDITORIAL WEBCAST DISCUSSION SERIES —
INSIGHTS, INSPIRATION AND INFORMATION

HOT SEAT

Next Gen Engineers

LIVE Webcast!
September 18, 2019
2 PM ET / 11 AM PT

Is design software prepared for next-gen engineers?

The Snapchat and YouTube generation raised on mobile devices, cloud-hosted apps, self-paced tutorials and touch-responsive screens have radically different ideas about how design concepts should be created, shared and tested.

Are engineering software makers keeping up with these socio-technological changes to accommodate the next generation?

In this **LIVE** webcast, panelists join *DE* to tackle the following questions:

- What are the developers doing to simplify complex CAD, simulation and PLM tools?
- What are they doing to make sure new tools don't get in the way of your creativity?
- How do they plan to evolve the user experience for the next generation without isolating current users?

Moderated by
Kenneth Wong
DE's Senior Editor

IN THE HOT SEAT

Matt Heying
Product Strategy
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TECHNOLOGY FOR OPTIMAL ENGINEERING DESIGN

INSIDE

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FOCUS ON IMMERSIVE DESIGN

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Spending Real Dollars on Virtual Reality

$160B
2023 Spending

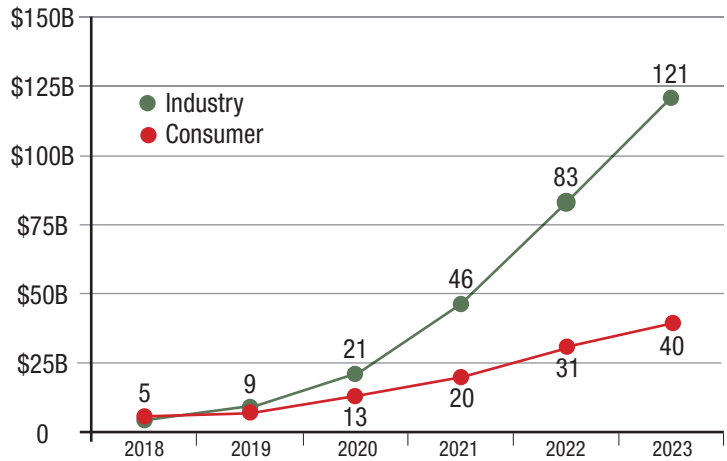
Worldwide spending on augmented reality and virtual reality (AR/VR) is forecast to reach $160 billion in 2023, up significantly from the $16.8 billion forecast for 2019.

The five-year compound annual growth rate (CAGR) for AR/VR spending is predicted to be 78.3%.

$16.8B
2019 Spending

— IDC's Worldwide Semiannual Augmented and Virtual Reality Spending Guide, IDC, December 2018 and June 2019

$121B 2023 Industry Spending



Globally, industry spending on AR and VR is outstripping the consumer market and will be triple its size within four years with a CAGR of 134%, vs. the consumer market CAGR of 69%.

— IDC's Worldwide Semiannual Augmented and Virtual Reality Spending Guide, IDC, June 2019

Extended Reality Markets

$815B by 2025

The global *augmented and virtual reality* market was valued at around $26.7 billion in 2018 and is expected to reach approximately $814.7 billion by 2025, at a CAGR of 63% between 2019 and 2025.

— "Augmented and Virtual Reality Market: Global Industry Perspective, Comprehensive Analysis and Forecast, 2018–2025," Zion Market Research, Feb. 21, 2019

$44.7B by 2024

The *virtual reality* market is expected to grow from $7.9 billion in 2018 to $44.7 billion by 2024, at a CAGR of 33.47% during the forecast period.

— "Virtual Reality Market-Global Forecast to 2024," MarketsandMarkets, July 2019.

$60.6B by 2023

The *augmented reality* market was valued at $11.14 billion in 2018 and is expected to reach $60.55 billion by 2023, growing at a CAGR of 40.29% during the forecast period.

— "Augmented Reality and Virtual Reality Market by Offering, Device Type, Application, and Geography - Global Forecast to 2023," ResearchandMarkets.com, May 2018.

Immersive Acceptance

69% by 2023

Sixty-nine percent of respondents expect AR/VR to become mainstream in the next five years.

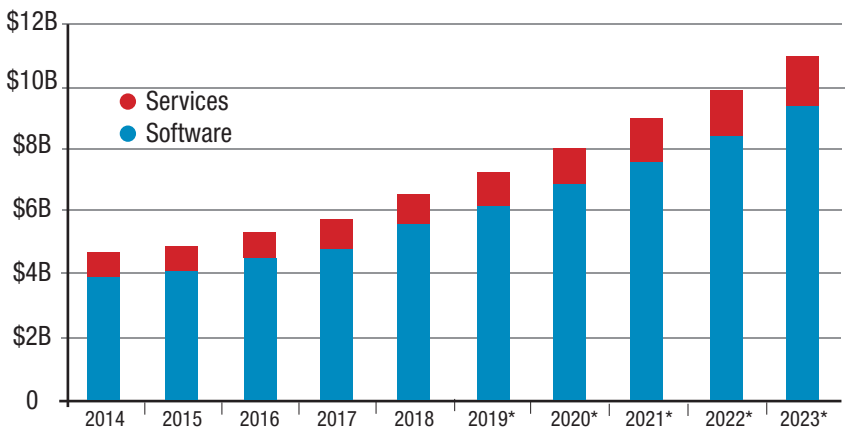
— "Augmented and Virtual Reality Trends Survey," Jabil, 2018

About 22.8 million AR glasses are expected to be shipped by 2020. The user base for AR technologies is also expected to grow beyond 1 billion by 2020.

— "Augmented Reality Market Size - Growth, Trends, and Forecasts," Mordor Intelligence, 2018

Sizing Up Simulation

$11B 2023 Revenues



In 2018 simulation and analysis revenues grew to nearly $6.5 billion, an increase of 13.1% over the $5.7 billion in 2017. For 2019, it is expected to grow 11.6% overall and have revenues of just over $7.2 billion. It is forecast to reach nearly $11 billion in 2023, with an 11.1% CAGR.

— "CIMdata Simulation and Analysis (S&A) Market Analysis Report," CIMdata, June 25, 2019

EDITOR'S PICKS

Each week, DE's editors comb through dozens of new products to bring you the ones we think will help you do your job better, smarter and faster. Here are our most recent musings about the products that have really grabbed our attention.

1U Server for HPC Features Cascade Lake Xeon

Microway Single Socket Server ready for the most demanding engineering tasks.

The NumberSmasher 1U 4 GPU Single Socket Server offers Microway's highest GPU/CPU density in a single socket compact rack footprint. It is designed for accelerated workloads that require a lower level of computation on the host CPU and most processing assigned to the GPUs. The 1U can support up to 4 NVIDIA Tesla V100 or P100 GPUs. The V100 is currently NVIDIA's graphics processing unit for data centers, ideal for engineering HPCs.

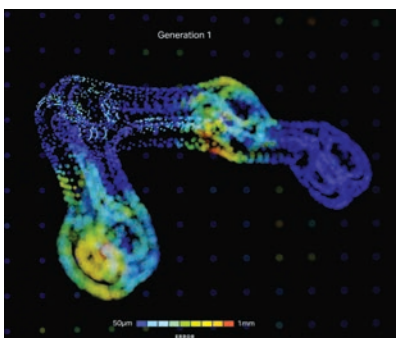
MORE ➜ digitalengineering247.com/r/22768

Core i9 and RTX Graphics Enhance Workstation

MSI WS65 mobile workstation offers rugged power for demanding work.

The MSI WS65 is a mobile workstation equipped with the NVIDIA Quadro RTX 5000, the next-generation top-of-the-line mobile GPU. The mobile versions of the RTX 5000 line have the same basic specs as NVIDIA's desktop models, re-engineered for the tight confines of the notebook workstation form factor. That means 3,072 CUDA cores, 48 RT (ray tracing) cores, 384 Tensor cores and 16GB GDDR6 RAM. This is an ideal configuration for heavy graphics applications in CAD and CAE.

MORE ➜ digitalengineering247.com/r/22744



Connecting Part Scanning to Part Printing

Using artificial intelligence to teach 3D metal printers how to improve results.

Markforged Blacksmith is a new software product that can adjust ongoing 3D print runs to ensure every part is produced as designed. To use it, a 3D scan of a printed part is compared to the original CAD model. If there are differences, Blacksmith automatically adapts the dataflow so the next iteration is in-spec.

The software uses machine learning to adapt as it is given new information, making the process of art-to-part more precise over time.

MORE ➜ digitalengineering247.com/r/22693

Real-Time Process Monitoring for Metal AM

Sigma Labs PrintRite3D Version 5 offers analysis of metal 3D printing quality.

Sigma Labs offers a solution for real-time structure analysis during metal AM part production. PrintRite3D is an in-process quality control platform. It combines inspection, feedback, data collection and critical analysis. The platform is hardware and software.

PrintRite3D gives manufacturers the ability to monitor and analyze key metal AM processes and to identify melt pool disturbances and other discontinuities as they happen.

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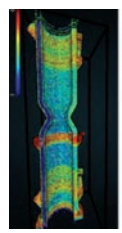
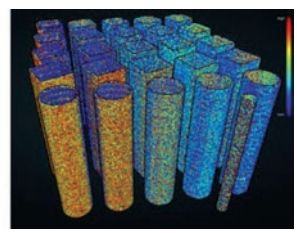




Get to **Work**

Mobile workstations for the workloads of the professionals who need them most.

WHETHER it's an engineer designing bridge structures on a major infrastructure project or a developer coding the next big video game release, the workstation is the epicenter of the workday and a barometer for employee productivity. A new paper, "Making the Case for the Right Workstation," explains what features to look for in a mobile workstation, and how to find the right tool for your job.

It's no longer enough to have a powerful desktop system stocked with the latest processors, storage, graphics capabilities and memory. Mobility is now a key requirement for workstation users. Today's architects, engineers, film designers, video game developers, data analysts and programmers want more than a secondary machine that allows them to do some basic modeling or animation work. Increasingly, they are looking to fully untether from their desktop, empowered to use their everyday 3D modeling, simulation, animation and analysis tools on the go.

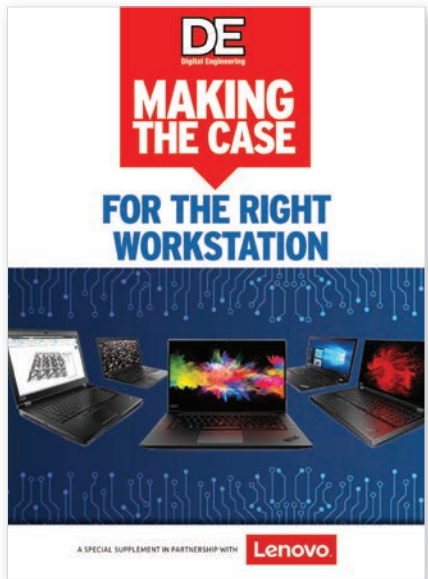
As projects increase in size and complexity, mobile workstations must be able to scale to meet the computational and graphical demands of modern-day workflows. Professional users want lightweight, portable devices that will deliver performance that's comparable to their desktop systems, including the ability to optimize power and resources for all of their workloads. At the same time, applications from leading independent software vendors in areas like advanced visualization, extended reality (XR), medical imaging, simulation and computer-aided design (CAD) must be certified to run at optimal performance on the mobile platform in order to ensure the highest levels of flexibility and productivity for a modern, professional workforce. Plus, as artificial intelligence is rapidly integrated into new and existing software vendors' applications to further accelerate productivity, hardware performance demands increase.

Innovation can now happen anywhere, so professional users across industry segments are demanding mobile workstations that meet performance, reliability, flexibility and security criteria.

Productive Performance

The recently updated Lenovo ThinkPad P Series is highly versatile, including the ultra sleek, 14-in. P43s, the 15-in. P53 that enables users to access mobile workflows that were previously reserved for 17-in. models, and the P73 with its 17-in. screen for multi-window applications and split screen multi-tasking.

The entire ThinkPad P Series portfolio has been designed to meet the highest reliability and durability standards. Just under 4% of Lenovo workstations require repairs in the first year, which is 16.9% lower than the industry average and 21.4% lower than the competitor average, according to the 2019 PC Reliability Study conducted by Technology Business Research (TBR). The ThinkPad P Series also features improved ThinkShield security capabilities and benefits from extra MIL-SPEC testing to ensure the mobile workstations can be used safely in the harshest environments.



DOWNLOAD Making the Case for the Right Workstation, a free 10-page paper produced by *DE* and sponsored by Lenovo, at digitalengineering247.com/rightworkstation.

For over 25 years, the ThinkPad portfolio of products has been defined by a commitment to simplicity, function, value and versatility. Even as technology advances at unprecedented speeds, Lenovo is devoted to the pursuit of innovation and constant process improvement, allowing users to focus on what's most important: Results and productivity.

Lenovo

NAFEMS World Congress 2019

BY JAMIE J. GOOCH

JUST A FEW BLOCKS from the fortified walls that surround historic Old Quebec, the simulation community gathered in the Quebec City Convention Centre June 17-20 to discuss all things simulation—including how to break through the walls that divide simulation analysts, design engineers and the larger enterprise.

NAFEMS World Congress (NWC), which takes place every other year, is organized by NAFEMS, the independent, international body that serves the simulation engineering community. NWC 19 ran concurrently with the 4th international Simulation Process & Data Management conference, and also hosted technical symposia focused on:

- Manufacturing process simulation and additive manufacturing,
- systems modeling and simulation,
- digital trends and what they mean for engineering simulation, and
- VMAP, a new interface standard for integrated virtual material modelling in the manufacturing industry.

With 330 papers across 10 tracks, 20 short courses,10 keynotes and more than 30 exhibitors, it's nearly impossible to cover the entirety of NWC 19. It's too big, with too many moving parts—a bit like systems engineering.

Model-Based Systems Engineering Explained

Professor Heinz Stoewer, founder of Space Associates GmbH and past president of the International Council on Systems Engineering, used his decades of experience as a professor of space systems engineering at TU Delft, and systems engineering work at the likes of Airbus, Boeing and the European Space Agency to answer one question during his NWC19 keynote: What is systems engineering?

Porte Saint Louis, a gate in the fortified wall that surrounds Quebec City, Canada. ***Image courtesy of Getty Images/diegograndi.***

"I could start by throwing out some 35 or more definitions of what systems engineering is or how the system is defined ... you'll be bored," he said. "I won't do that."

Instead, he used an example of a rocket engine to explain systems engineering by showing why:

1. Anybody's system is somebody's subsystem.
2. We need systems engineers at all levels of system integration.
3. The job of a systems engineer is to add value.
4. The art of systems engineering comes in the feedback loops that lead to iterations back to the stakeholders that lead to the right design.
5. System complexity is growing faster than our ability to manage it, increasing the risk from inadequate specification and incomplete verification.

Stoewer said the job of a systems engineer is to push down on the risk curve, so by the time you need to make development and production commitments, your risks are understood and mitigated.

"Failures result from lack of planning and insufficient time for early R&D verification and design," he said. "If you spend more effort in the early phases, the probability that you'll be on target is much higher."

Part of the solution to growing complexity is model-based systems engineering (MBSE) and analysis connected to all stakeholders via a digital thread. "CAD/CAE vendors are trying to evolve from the bottom up, and some of the MBSE vendors are trying to move top down," he said. "The question is when will they meet? They need to meet, is my point. We need to move from independent tools to a digital tapestry."

The most important goal may be to transform the culture of the workforce, Stoewer said, calling it the real issue. DE

MORE → nafems.org/congress/keynotes/

HxGN Live 2019

A FEW corridors away from The Venetian's neon-lit jungles of poker tables and slot machines, Hexagon Manufacturing Intelligence's (Hexagon MI) president and CEO Norbert Hanke proposed some navigation tips out of the data forest.

In his keynote "Smart is hiding in plain sight," Hanke said, "Ich seh den Wald vor lauter Bäumen nicht," the German version of "You can't see the forest for the trees." Manufacturing, he argued, is "obsessed with the trees. Everyone is looking after their tree, their silo, their own path in the process. Trees are, to a certain extent, the status quo. We need to look beyond the trees and see the forest."

Hexagon's roots are in metrology, the devices and technologies for precision measurement. But through a mix of acquisition and organic growth, the company has broadened its portfolio to include simulation, location-based intelligence and manufacturing, among others. In 2017, the company purchased MSC Software, known for its CAE offerings.

The proliferation of augmented reality and virtual reality demos at the recent show suggests Hexagon MI is also looking at the intersection of metrology and the emerging mixed reality applications as a new frontier to conquer.

"We need to move beyond the status quo. Let's not treat design, production, and metrology as functional silos anymore. They rely on one another," said Hanke. "The goal should be "to put data to work, to empower an ecosystem that's connected and increasingly autonomous."

Sheet Metal Cost Estimate

FormingSuite, a sheet metal design software package from Forming Technology Inc., a division of Hexagon, hints at how to put process data in manufacturing to good use. "FormingSuite's ability to provide extensive valuable information on many topics including formability, material cost, tooling cost, springback, etc. has led to the introduction of a new, comprehensive reporting system that automatically generates a single report summarizing an entire project," according to Hexagon.

"We're trying to move that same concept to other processes," said Paolo Guglielmini, CEO of MSC Software. "We have so many customers in injection molding, welding and additive manufacturing. As a result, we have a powerful set of data on material use, machining, surface treatment and metrology inspection. We can use it to do sensible, reliable cost estimation from the get-go."

Beyond the presentations and training, HxGN attendees also had the chance to take flight, virtually. ***Image courtesy of Hexagon MI.***

Guglielmini envisioned implementing cost estimation tools for the designers, who he believes should drive the process. "You don't want this to happen post-design. You want to do this early to control the cost," he added.

Guglielmini also revealed the company is looking at composite and additive manufacturing (AM) as the two areas of growth and innovation. Thus, these two segments are the focus of its cost estimation tool development.

MORE ➜ digitalengineering247.com/r/22814

Augmented World Expo 2019

AT THE END OF MAY, hosting the Augmented World Expo (AWE) 2019, the Santa Clara Convention Center packed in more than 7,000 augmented reality (AR) enthusiasts, developers and investors. This year was the 10th anniversary of the event, produced by the nonprofit AugmentedReality.org. The organizers' goal—their "moon shot," to borrow their words—is to "inspire 1 billion active users by 2020."

"Facebook announced this month that 1 billion people have tried AR experiences, but they are not necessarily active," noted Ori Inbar, founder of AWE. "The current estimate by [AR-VR market watcher] ARtillery and [game data tracker] Superdata is, about 700-800 million users are monthly active users of AR and VR. So it looks like we'll achieve the milestone by the deadline."

In its report on AR Commerce, ARtillery projects, "$6.1 billion in annual transaction value will flow through AR interfaces by 2022." According to Superdata's published chart on mobile AR usage, the mobile AR user base has already surpassed the one billion point. Superdata projects mobile AR user base to reach 1.7 billion by 2020.

Some of the AR systems on exhibit at AWE 2019 look more like fashionable eyewear than clunky headsets that draw attention. Lenovo's ThinkReality and nreal signal a shift to power the devices with small portable smartphone-size computing units. This approach quite literally frees up the user. Without being attached to workstation or PC via a cord, the user can exercise a wider range of motions in interacting with digital objects in the augmented or virtual world. DE

MORE ➜ digitalengineering247.com/r/22718

Are You XR Ready?

Identifying the right use case is key to getting the most out of enterprise AR.

BY KENNETH WONG

IN VOLVO'S RESEARCH FACILITIES in Sweden, test drivers are becoming accustomed to operating future car models that only exist as pixels. The car on the road is a physical vehicle; but what the drivers see is something else. Outfitted with Varjo's XR-1 augmented reality (AR) device, they see the interior of a car not yet manufactured.

"With this approach, we can, for the purpose of evaluation, use different virtual display options of the dashboard to see how drivers perceive them while driving the car. So, wearing the XR-1 headset, the driver 'sees' the virtual dashboard in the car, which in reality does not yet exist," Volvo's press office explained in an email to *Digital Engineering*.

It's just one example of how AR fuses physical and virtual products, and enables design review and testing that is otherwise impossible. Ray-traced, rendered videos give you impressive visuals. Software-based simulation helps you figure out how a product might fail. But AR lets you experience a virtual product as though it were physically present. From automotive and aerospace to consumer goods, many manufacturers are looking at extended reality as the new frontier in product development.

But AR enterprise adoption is not plug-and-play. Without adequate preparation, projects can easily go awry. For this article, we spoke to those who have gone through the journey to understand what it takes.

Driving Pixels

Headquartered in Helsinki, Varjo launched its first virtual reality headset called VR-1 in January this year, calling it "the first human-eye resolution VR." In its announcement, the company wrote that VR-1 has "a resolution of more than 60 pixels per degree, which is 20X+ higher than any other VR headset currently on the market. VR-1 also comes with the world's most advanced integrated eye tracking, enabling high-precision analytics and

interaction with human-eye resolution VR content." In May, the company launched its first AR headset, called XR-1 Developer Edition, using the term XR for extended reality.

The eye-tracking technology in VR-1 and XR-1 allows the user to use their eyesight—and where they choose to focus—as a pointer. Without the need to use controllers to select and execute commands, the system leaves the user's hands free for other tasks. In driving simulation, the feature is particularly important as the test driver needs his or her hands to control the steering wheel.

"The highly accurate eye-tracking technology embedded inside the XR-1 makes it easy to assess how drivers use a new functionality and whether they are distracted in any way while driving," said Volvo's press office. "This technology-based approach to measuring distraction levels ensures that Volvo Cars can develop new features without causing additional distraction. Therefore, wearing the XR-1 headset while actually driving gives us real insights, which we can take into the development of our cars."

Volvo is not just a customer of Varjo, but also an investor. The Volvo Cars Tech Fund is supporting the startup headset maker's ongoing developments. "For using mixed reality (MR) in product development most optimally, it should be integrated into existing workflows to enhance and improve existing systems rather than creating completely new ones from scratch," advised Volvo.

A test driver for Volvo wears a Varjo XR-1 AR headset to see the virtual dashboard of a new model under development. ***Images above and opposite courtesy of Varjo and Volvo.***

Props Make a Difference

While Elizabeth Baron was working as the immersive reality technical specialist for Ford, she oversaw the creation of an VR setup that let engineers perform surface highlights on vehicles that had not yet been built. To replicate the way automotive engineers would shine a light on a car to observe the reflections, she assembled suitable VR headsets with position tracking.

To make the VR session much more realistic, Baron made one significant tweak. "I went to the dollar store nearby, bought a bunch of 12-in. flashlights, and tracked them," she recalls. "In most cases, it's advantageous to have a physical object that represents the real device the user would naturally be using for the task."

In shape, proportion and function, the cheap flashlights were much closer to the real equipment the engineers would use for their routine surface highlight tests. The modification, which came at a small cost, made the VR setup so convincing that, when the session was over, the users were often attempting to switch off the dummy flashlights, which were never turned on to begin with. "We always got a kick out of watching them do that," Baron says with a chuckle.

Baron left Ford in the beginning of 2019 to start her own firm, Immersionary Enterprises. She recently started a collaboration with Silverdraft Supercomputing. "I want to work with enterprise clients on their XR journey, to work on both their culture and technology to enable better collaboration," she says.

The New Medium for Collaboration

If you peel off the glossy visuals in many multi-user MR applications, you'll often find underneath the all-too-familiar features from WebEx, Skype and FaceTime. At its core, the NVIDIA Holodeck is nothing but a massive group chat environment with ray-traced visuals. Certainly, inside the Holodeck, participants get a much deeper understanding of the design, engineering and manufacturing issues they face because they can inspect a life-size digital replica of the product as though they were standing in front of it. But the tools for voice communication, text messaging and screenshot snapping are nearly identical to those found in Skype or Facebook messenger. This is both good and bad.

It's good because the similarities allow users to ease into the new medium without significant culture shock. But bad because the same similarities may make users miss the fundamentally different ways an XR workflow needs to be supported.

It's fairly straightforward to set up and support a multi-user collaboration system with the backend mechanism to automatically capture and archive the sessions on a public or private cloud. But setting up and supporting a similar type of workflow in AR, VR or MR, however, has different storage requirements, due to the large amount of 3D data and photorealistic video streams involved.

Baron designed a global immersive collaboration paradigm in 2012 and did the first immersive review between Michigan and Australia in 2012. "I saved a lot of XR discussions to record what happened in the meeting, thinking people would go back to review them, but nobody did," reveals Baron. "So we learned that saving a summary of what was learned during the session is a better strategy."

Identifying the Right Use Case

Realtors like to quip, "There are three important aspects to buying and selling properties: Location, location and location." Ask David Nedohin, president and cofounder of Scope AR, about AR adoption and you'll get a similar response.

"The three most important aspects to successful enterprise AR engagement are the right use case, use case and use case," he says. "Companies have to figure out the use cases that make the most sense. After that, then they can align the necessary workflow with the current technology available and figure out how to support that."

One general use case Scope AR is betting on is remote

Epson is among the device makers betting on remote expert assistance as an area for AR application. Recently it launched the Epson Moverio Assist on-demand services. ***Image courtesy of Epson.***

assistance. To enable it, the company offers an integrated AR content-authoring platform called WorkLink. The platform allows organizations to create and publish AR-powered work instructions.

"The software facilitates real-time remote assistance video calls between a technician and a remote expert. While on a live video call, the expert can see the real-world view of a colleague on the shop floor, for example, and walk him or her through a repair or maintenance procedure by annotating the view with animated, 3D digital content or by dropping in a set of pre-built AR instructions for the technician to follow," explains Nedohin.

Although Scope AR's software remains hardware agnostic, Nedohin believes certain AR gear offers clear advantages over others. "To me, without a doubt, the Microsoft HoloLens 2 with its computer vision is one of the best devices for our applications," he notes. "Aside from camera and processor power, it largely comes down to the use of top-of-the-line computer vision technology to map out the natural environment for virtual object placement."

An Easy Entry to AR

Hardware makers such as Lenovo and Epson are also gunning for remote expert assistance as a low-barrier entry to AR. At the recent Augmented World Expo (AWE, Santa Clara, CA, in late May), Lenovo launched its first enterprise-targeted AR glasses, called ThinkReality A6. To attract application developers, the company also released the ThinkReality software platform, which includes sample apps for AR/VR applications. One of them is a remote expert communication app.

Around the same time, Epson launched Moverio Assist, a System-as-a-Service product to set up and deliver remote expert assistance via Moverio AR glasses (specifically for Moverio BT-300, Moverio BT-350 and Moverio BT-350 A). Users buy the supported AR glasses and supply their own expertise, but Epson provides the cloud-hosted communication pipeline to let the field technician and the expert connect, troubleshoot and share files.

"For remote assistance, you just need a set of basic features: front- and back-facing cameras, two-way audio and file sharing. We see this as an easy onramp to get companies up and running in AR. It's self-service, no onboarding process," explains Leon Laroue, technical product manager for Epson Moverio.

With Epson's Moverio AR glasses, the field technician may from time to time use a portable smartphone-size pointer to select and open files, but for the most part they can work hands free. Compared to the clumsy use of a smartphone's video camera to transmit and work on machinery at the same time, the AR-powered approach is a better alternative.

"We built the Moverio Assist with scale in mind, so it doesn't matter if you're a company with five or 5,000 users. It's ideal for the industries where, if your machines are down, appliances need

to be repaired or equipment needs to be installed, downtime is measured in hundreds of thousands of dollars," says Laroue.

With an AR-based remote expert program, the expert sitting behind a computer can guide a field technician to perform certain complex tasks that require a deeper level of knowledge. This approach cuts down on the expert's onsite visits, and allows him or her to service more sites and handle more cases.

Hands Free, Gesture- and Geometry-Aware

Over the years, AR and VR gear has improved in form factor, resolution and function. The latest generation is much lighter, making it easier to wear and work for an extended period. Many now include or are striving to include hand tracking, gesture recognition and environment awareness.

At February's Mobile World Congress in Barcelona where the Microsoft HoloLens 2 debuted, perhaps one of the most groundbreaking moments was when Julia Schwarz, Microsoft's principal software engineer for HoloLens 2, played a virtual piano by tickling the invisible ivories with her real fingers.

With the HoloLens 2, Microsoft incorporated gaze and air tap functions. This allows the user to use their head gaze as the targeting mechanism (what you would normally do with a mouse pointer on a flat screen); and the tap gesture in the air as the trigger mechanism (the equivalent of a mouse click on a flat screen).

"Tracking technology has blossomed, and today's headsets give you better pixel density. They're a lot lighter. They know where you are. They're much better at anchoring virtual things on real surfaces. When I was at Ford, around 2010 or 2011, I used only mocap," recalls Baron. In addition to mocap, or motion capture, Baron later integrated more tracking technologies such as SteamVR.

Motion capture allows you to capture the physical action of actors and map them onto digital avatars. Although it results in highly realistic physical movements, it's also costly due to its complex setup and space requirements. Later, Leap Motion's small motion detector (price beginning around $90) became an easy and affordable way to implement hand-gesture recognition. In May, the UK-based Ultrahaptics snatched up Leap Motion for $30 million.

Today's AR and VR gear with built-in depth cameras, motion sensors and location awareness makes mocap unnecessary in many cases. The headset's own awareness of where it is, along with its ability to recognize and track finger joints, fills in the previously missing pieces. The gear makes it much easier to translate the headset user's body gestures and movements into the virtual world, allowing software developers to add new physical-digital interactions for amusement as well as practical purposes.

"Hand gesture recognition is extremely important for AR-based maintenance in automotive and aerospace engineering. You want the user to be able to get inside an assembly and find wiring harnesses, for example," says Baron. The headset's ability to map its physical surroundings is also critical because, "in automotive, sometimes you want to look at a whole different virtual front on an existing car."

Those who want to develop AR-based design review may consider building physical rigs with easily recognizable surfaces where virtual objects can be slapped on. Thus, the physical setup provides the tangible sensation (weight, mass or texture) of the imaginary product, while the view in AR or VR delivers the visual layer.

Avoid Unnatural Interfaces

AR, as the acronym suggests, allows you to augment reality with digital objects. As Baron has learned from her time at Ford, unnatural user interfaces prove to be detrimental to such use cases. "Don't give someone a game controller, and tell them, hit that button to do X, swipe left to do Y," she advises. "Avoid user interfaces that don't work the way people would naturally work in the real world."

In maintenance and repair exercises, users need to not only learn the correct placements but also build muscle memory—something software application developers often forget. In the virtual world, you may be able to punch through a cluster of pixels to reach for a wire harness in a tight spot. A technician trained to install or repair something in this unrealistic setup is liable to fail when confronted with the laws of physics in reality.

"Often, what you need to do to prepare for AR is not just technical; it's also cultural," says Baron. XR can let a mechanical engineer show a designer why certain pillars and wiring harnesses need to be repositioned to avoid collision, but if the company doesn't have a collaborative culture that encourages mechanical engineers and designers to work together, outfitting them each with a pair of $3,500 HoloLens 2 smart glasses won't help. DE

Kenneth Wong *is* DE*'s resident blogger and senior editor. Email him at de-editors@digitaleng.news or share your thoughts on this article at digitaleng.news/facebook.*

INFO ➜ Augmented World Expo (AWE): USA2018.AugmentedWorldExpo.com

➜ **Epson Moverio Assist:** Epson.com/Moverio-Assist-virtual-remote-assistance-inspections

➜ **Immersionary:** Immersionary.net

➜ **Lenovo:** Lenovo.com

➜ **Leap Motion:** LeapMotion.com

➜ **NVIDIA Holodeck:** NVIDIA.com/en-us/design-visualization/technologies/holodeck

➜ **Scope AR:** ScopeAR.com

➜ **Varjo:** Varjo.com

For more information on this topic, visit DigitalEngineering247.com.

Standalone **Holographic Display** Launched

BY KENNETH WONG

AS A STATIC DISPLAY unit, The Looking Glass Factory's holographic display box offers the Wow factor, but not much else. However, interactivity and built-in compute power bring the latest incarnation of the company's technology to a whole new level.

The company has been developing and selling the displays for about three years now. The latest addition to the company's portfolio is the Looking Glass Pro. The Pro doesn't need a connection to a PC or workstation. It had its own built-in Intel NUC 8 VR NUC8i7HVK computer, a 15.6-in. display area and weighs 25 lbs.

From CAD to Holograms

The display units support content authored in Unity, Unreal, Three.js and more. You load the model into the Looking Glass environment as OBJ, FBX and other neutral 3D formats exportable from CAD programs. The company has assembled about three dozen holographic content and games, freely accessible to users.

Looking Glass's front-facing surface is touch-responsive, so you can use pinching, poking, stretching and other standard methods to zoom in, pan and rotate the loaded 3D models and scenes. But upgrading the display with an Interaction Accessory Pack (a Leap Motion sensor) brings more interactivity.

Leap Motion, a motion-detection sensor the size of a Starbucks coffee mint box, can translate hand positions and gestures and apply them to the holographic objects. If the loaded model contains proper physics and kinematics, you can, for example, poke, punch or pull on it to get realistic responses.

New Ways to Get Instant Simulation Feedback

In demonstrating the Looking Glass displays, the company often uses the 3D human heart model created using Dassault Systèmes' 3D EXPERIENCE technology, suggesting the CAD-to-hologram conversion process is not difficult.

If properly adapted, the Looking Glass holographic display could offer new ways to apply stresses and loads in 3D models in simulation software. Currently, in the 2D-driven mouse-and-keyboard paradigm, you need to rotate the model, select the surface and apply the forces as numeric values. But what if you can simply press down or pull on surfaces and structures to see deformation as instant feedback? It's a vision The Looking Glass cofounder Alex Hornstein wants to explore.

Looking Glass Pro has built-in computing and a touch screen. *Image courtesy of The Looking Glass Factory.*

"Right now, you can do simple tasks, like displaying scenes built in SIMULIA in Looking Glass for marketing purposes," he says. "But the best approach is a native-level integration with SIMULIA. With that kind of approach, the holograms in Looking Glass can retain the same model joints and constraints in SIMULIA. It's something we're interesting in pursuing in collaboration with Dassault Systèmes SIMULIA," says Hornstein.

If you bring CAD assemblies into AR-VR (augmented and virtual reality) environments or into The Looking Glass display as neutral 3D file formats, you usually lose the assembly mating conditions. Only a native-level integration would allow you to retain such intelligence. If an assembly model can retain such detailed kinematics in the AR-VR environment or holographic displays, it could be a foundation for visualizing digital twins. DE

INFO ➜ Dassault Systèmes: 3ds.com

➜ **The Looking Glass Factory:** LookingGlassFactory.com

For more information on this topic, visit DigitalEngineering247.com.

Image courtesy of Getty Images/gorodenkoff.

Can AR **Enhance** Design?

Though augmented reality brings benefits for collaboration and design review, hardware limitations make engineers wonder about its viability.

BY TOM KEVAN

PROPELLED BY A NEW GENERATION of hardware and software, augmented reality (AR) appears poised to assume a significant role in product design. But how much of this perception is based on hype, and how much actual value will the technology add to the design process? Will AR technology dominate the design and development field, or will it be coupled with complementary technologies?

Before companies adopt AR technology and select a platform, they have to understand what this particular immersive technology offers, examine its strengths, recognize its shortcomings and decide if these visualization platforms will deliver enough value to their development efforts to justify the expenditure of time and resources to incorporate them into their designers' toolkits.

Taking Design to the Third Dimension

Developers of the immersive technology have been working to leverage the technology's chief strength, visualization, which has long been a core element in the design process.

Until recently, designers relied on CAD modeling, rendering and simulation to envision and shape product concepts early in the development process. Unfortunately, the constraints imposed by computer screens have hampered designers, with the 2D medium suffering from disconnects between the design concepts and the realities of scale and spatial context.

To break free of these constraints, AR system developers offer interactive visualization, promising to help designers shift from passive viewing to an immersive experience. This type of visualization has the potential to provide engineers with the ability to choose multiple paths of exploration, allowing them to examine relevant points of interests from different angles and at various scales. In addition, AR can visualize clusters of interrelated data. With simultaneous access to different data sources, design teams can make better informed decisions.

AR systems can also help engineers place their designs within the actual context of use and interact with their ideas, rather than try to glean insights by studying static images on screens. A real-time environment lets designers assess how a design responds to various conditions. It further enables engineers to understand connections between operations and product performance.

The challenge now confronting design teams is in determining the extent to which these promises are true.

Blending the Digital and Real Worlds

AR aims to provide an interactive experience, where the system overlays digital data on a real-world environment in such a way that it is perceived as an immersive aspect of the real environment.

The technology's developers claim that their systems give designers the opportunity to manipulate 3D models with their hands and allow them to place design concepts in the real world, where they can walk around models and get a feel for form, proportion, mechanical processes and the product's relationship with the environment.

"This is exactly where displaying results from a simulation on top of the real product can be extremely useful," says Nicolas Dalmasso, chief technologist at ANSYS.

"It can help engineers and designers better understand how the product they are developing behaves within its real environment. For example, while developing HVAC [heating, ventilation and air-conditioning] systems, displaying CFD [computational fluid dynamics] results within the AR device on top of the real car really helps in the understanding of how shapes affect fluid propagation while adding the user within the environment."

"Interactions with the virtual product are far from being 'natural.'"
– Nicolas Dalmasso, ANSYS

Incorporating semantic information or metadata from CAD systems directly into the AR environment can help explain or present product specifications during design reviews. For instance, gap and flush information, material properties and part information aid decision-making when reviewing the designed product.

"During the process of visualizing or creating an idea, there are many pieces of information required throughout the process: product specifications, interface specifications and resource requirements for every addition of a new or improved feature," says Therese Fessenden, user experience specialist at the Nielsen Norman Group.

"Designers regularly must stop what they are doing mid-task to gather information that is not immediately on hand," she says. "With AR, designers can continue working, dedicating mental energy toward the task at hand, without leaving or distracting themselves to gather that additional information."

AR's visualization strengths also include projection mapping, which has proven suitable for very large products or contexts. This feature, however, comes with a caveat.

"Space and relatively static locations become a limiting factor," says Eric Kam, manufacturing business channel marketing and alliances director at the ESI Group.

With these features in mind, proponents of AR assert that the technology's strengths can accelerate time to market and add new dimensions to collaboration. That said, the technology faces challenges that affect the productivity at the designer's workbench.

Hardware Shortcomings, Performance Limitations

Some obstacles compromising AR's ability to deliver enhanced visualization relate to hardware limitations. For example, consider the delivery devices used by AR systems. The devices fall into four general categories, each facilitating immersion to varying degrees. These include heads-up displays, holographic displays, smart glasses and handheld systems. The current technology suffers from shortcomings that prevent AR devices from achieving their full potential.

"Notable barriers for real AR adoption are lack of resolution, dynamic range and field of view, which are far from what a human eye can do," says Dalmasso.

In addition, AR system providers also must address problems within the systems' interaction capabilities.

"Interactions with the virtual product are far from being 'natural,'" says Dalmasso. "Lack of haptic feedbacks and difficulty tracking gestures are some of the limitations slowing down adoption. Analyzing gaze (eye tracking) and some other human actions, such as voice, could help improve understanding of the user's intent."

AR device developers are still grappling with ergonomic issues. Users still find current AR systems relatively intrusive. Wearable devices can be heavy and cumbersome, and tethered systems can distract users while they are attempting to perform their task.

Developers could address these issues by reducing the size of the device, but if they do so that generally comes with a limitation of computation power. As a result, developers of these systems face tough trade-offs in balancing power demands with form factor limitations.

Power limitations present more of a challenge than ergonomics for AR devices. This points to an even larger problem facing designers using AR.

"Current AR devices have limited compute capabilities and limited memory, which generally causes the devices to struggle to perform computationally intensive tasks," says Dalmasso. "For example, AR devices generally come with limited GPU [graphics processing unit] capabilities, preventing them from using state-of-the-art rendering techniques like real-time ray tracing or complex lighting rasterization. As a result, a photorealistic or physically correct rendering of a product cannot be easily achieved within an AR environment."

Prepping Data for AR

The constraints imposed by limited compute resources also hinder AR systems' ability to process CAD data into a usable format for AR systems. Many AR systems simply have limited ability to render full CAD models.

"When discussing graphics with extended reality [which includes AR] professionals, you will find yourself often discussing

numbers of polygons as a way of describing modeling complexity, since all the 3D models will at some point be broken down from complex solids into collections of smaller, more discrete polygonal or tessellated models," says Kam. "The number of polygons that can be rendered in a 3D view is limited by the available computing power on the CPU and GPU of the extended reality system."

Most—if not all—stand-alone, mobile device and handheld AR systems cannot load large polygon models. CAD data of something like a fully modeled automotive engineering dataset likely consists of tens or hundreds of millions of polygons, which exceeds the capacity of AR devices.

Therefore, designers using AR systems must perform an additional step, optimizing and simplifying the models' geometry so that it fits the "low-poly" requirements of the device. Unlike full CAD model poly counts, these "low-poly" requirements are often measured in the tens of thousands of polygons or hundreds of thousands of polygons. This process reduces complexity and makes it possible to load and use the data in lightweight viewing.

An additional step called decimating reduces the model size by a factor of 10 or 100. Unfortunately, this process introduces inaccuracies in the representation of the model.

In other cases, engineers might manually "cull" the data by eliminating some CAD objects that they decide might not be needed for the immersive review. This introduces the risk that the engineer might cull influential objects for the intended review, in effect whitewashing (or greenwashing) the very problems that the review was meant to identify.

"For most engineering teams, this is a non-value added step," says ESI Groups' Kam. "It also introduces the chance that during the optimization of data, decision-making relevant data is simplified in a way that masks a potential issue."

Automated Processing of CAD Data

Moving models from CAD systems to AR systems becomes problematic for a number of reasons. Designers run into roadblocks thrown up by shortages of compute resources. Furthermore, using existing simplification, optimization and decimation processes exposes the design to complications that slow and even compromise the development process.

The questions that surface include: Would these problems go away if the two systems were tightly integrated? Would this eliminate or mitigate the challenges arising from the need to transfer data between the two systems? Companies like PTC believe the answer to both questions is "yes."

"It's a multi-step process with errors and losses of time at each end," says Luke Westbrook, product management specialist, PTC. "AR should never be a separate, labor intensive tool. If you're switching between different tools, that's suboptimal.

"The way we see it, users shouldn't have to worry about optimizing anything to efficiently work in an AR environment," he says. "But for this to happen, the CAD, simulation and AR tools need to be tightly integrated. The optimization should be done on your behalf and put into a format for the AR viewer."

What Does the Future Hold?

Attempts to see what the future of AR holds inevitably lead to face-offs between AR and its chief competitor, virtual reality (VR). There is the assumption that one of these technologies will rise to the top, while the other fades into oblivion. That probably won't happen.

"I think that AR and VR don't have to be placed in such mutually exclusive buckets," says Kam. "Instead, there are likely many workflows where the two display and visualization technologies are complementary."

In the near future, advanced forms of AR devices will likely incorporate elements commonly associated with VR. This is why futuristic AR headsets like HoloLens glasses are often confusingly described as "mixed reality" devices. (See page 20 for more on mixed reality.)

Thoughtful consideration of the potential of the two technologies ultimately reveals that the binary distinction between AR and VR creates an inaccurate picture of the evolutionary path of immersive technologies. The fact is that the future will likely belong to devices that combine elements of both. DE

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INFO ➜ **ANSYS:** ANSYS.com

➜ **ESI Group:** ESI-Group.com

➜ **Nielsen Norman Group:** NNGroup.com

Is Mixed Reality Worth a Try?

The visual technology holds much promise for design review and collaboration, but still faces limitations in hardware and processing power.

BY TOM KEVAN

SCIENTISTS ESTIMATE THAT 80% to 90% of the information processed by humans occurs through the sense of sight. For design engineers contending with the gap that exists between the physical and digital worlds, this can be a problem. Developers of mixed reality (MR) systems, however, aim to give product designers the means to bridge this gap by integrating the two forms of data in an environment that plays to the strengths of humans' ability to digest visual information.

How do they plan on doing this? By returning to the basics. The advantage in mixed reality systems lies in the form in which information is presented and the context in which it is applied. To achieve this, the developers of these systems have turned to existing and proven technologies: virtual reality (VR) and augmented reality (AR). What is of significance is how the two are combined.

Two Ways of Viewing It

As if a technology that represents a mix of two systems is not confusing enough, the MR label has two meanings. It can be used as an independent concept or to classify types of reality technologies.

The broader interpretation, referenced in the reality-virtuality continuum, describes the coverage of all possible variations and compositions of real and virtual objects. The continuum ranges from a completely real and natural environment to a completely virtual environment.

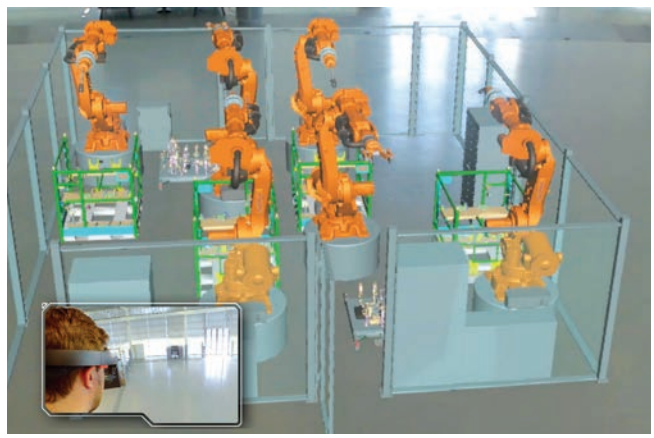
Developers espousing the independent concept, however, see MR as a combination of the best features of virtual reality and augmented reality. This approach produces visualizations in which physical and digital objects co-exist and interact with each other in real time.

A Question of Context

Similar to AR, MR superimposes digital content (e.g., text, 3D graphics, sound and video) onto the backdrop of a real-world environment. By placing information in context and allowing the user to simultaneously see elements of both worlds, MR helmet-mounted displays (HMDs) greatly enhance the user's ability to consume and process information.

The element that sets MR systems apart from AR systems is that MR content appears in the form of a hologram within the actual real-world environment, an approach that eliminates the constraints of conventional 2D visualizations.

With MR headsets and gloves, designers can use hand gestures and voice commands to manipulate and interact with their designs as if they were real objects, walking around and looking inside the design. In addition, MR allows users to see the real world alongside virtual objects anchored to a defined point, helping users to treat them as real objects.



Mixed reality places a holographic projection of digital data into the physical world. This allows development teams to determine if their design fits into the space allotted by the application and to ensure that there is adequate room for adjacent structures or equipment. ***Images courtesy of Theorem Solutions.***

Until recently, Microsoft's HoloLens smart glasses dominated the MR market, but an HMD from Magic Leap blends holographic data with the real world in a way that some claim represents a significant advance toward the provision of true spatial context for the user, aiming to place full-sized, 3D digital data into the physical world.

What's the Appeal?

Even after hearing about some of MR's more impressive features, design engineers inevitably may ask: How will MR enhance the

product design process? What will the hybrid visualization technology let engineers do that they can't already achieve with more established enhanced-reality tools?

MR system advocates say that by taking the best of AR and VR, the hybrid systems deliver richer interactions, enhanced efficiency and greater flexibility.

"The idea that you can look at a complex system and modify it can be particularly appealing," says Todd Zielinski, senior director of electrical engineering for the Bresslergroup, a design consultancy based in Philadelphia. "AR allows you to see and potentially diagnose problems or add information in a spatial context, while MR implies you can now interact with that system in a more meaningful way in real time."

MR's efficiency entails streamlined design processes, greatly enabled by the VR element of the MR system.

Very early in the design process, when there are few physical objects accessible to serve as design aids, VR is instrumental in helping design engineers to view their designs before they are made and experience key design concepts. Engineers can take their CAD designs, merge that geometry with the contextual geometry of neighboring components and digital human models, and gain a real sense of how users will interact with the new product.

"Interaction modeling is examined and tested early in the process, which helps significantly in defining the operation of the product, and what features it must have—and how they work—in hardware and software," says Zielinski. "This helps minimize the time spent on product development due to missed or incorrect requirements by pushing system modeling earlier in the design process."

Once engineers immerse themselves with the products in their chosen context, they can conduct engineering reviews, which normally would not occur until after parts are available. This effectively lets designers jump months, or years, into the future. If any shortcomings emerge in the design surface, development teams can evaluate mitigating options or redesign the product and then determine if the changes address the shortcomings.

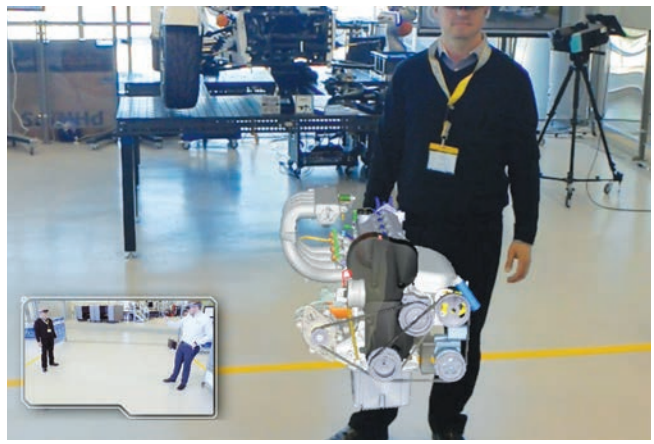
These advantages help development teams reduce the amount of time their products are in design because a virtual prototype can be created in short order. "This is a very fast, iterative process—even faster than 3D printing of prototypes," says David Francis, chief marketing officer for Theorem Solutions.

In addition, MR systems promise to smooth the transition from design to manufacturing, holding out the potential for an end-to-end efficiency improvement. "The design can be checked [so] that it can actually be assembled," says Francis. "Can you get a wrench or screwdriver into a restricted space? Can the material be formed as the designer has designed? Can a welder actually get the equipment into that space to create a proper weld? Is the design safe? With mixed reality, you can use the actual tools on the holographic/virtual product."

An MR Workflow

Typically, an engineer begins working with an MR system by taking the relevant 3D CAD files and preparing them for use in a virtual environment. This means translating them into a lightweight format suitable for use on an HMD, smart glasses or a tablet.

To accomplish this, the designer processes the 3D CAD models, optimizes and decimates them so that the MR system can visualize them. The system then displays the data in immersive 3D.



Mixed reality headsets such as Microsoft HoloLens 2 or Magic Leap One allow designers to view and interact with digital data, such as CAD models, in the actual working environment rather than on a 2D screen.

Moving Toward Greater Collaboration

These immersive 3D visualizations open the door for greater collaboration among development team members, supporting an interactive quality previously unheard of before the introduction of VR technology.

"The real power comes when multiple users are viewing the data collaboratively," says Francis. "For example, Theorem's software allows multiple engineers using MR headsets to view the data in the same session. The assembly appears as a hologram that can be interacted with by all participants—although one at a time. If they are in a remote location, then they appear as an avatar to their colleagues. VR, MR or desktop devices can all be used concurrently. Discussions around the design can be annotated with video/audio or text remarks, which are accessible following the review."

As impressive as this sounds, how do MR systems stack up against pure VR systems for collaboration?

For example, when handling large assemblies like airplanes, can MR headsets deliver the same level of performance as a VR-based cave automatic virtual environment (CAVE) or powerwall systems?

In these applications, MR systems can fall short. "Massive assemblies such as entire airplanes or ships can be modeled and viewed in mixed reality, and through collaboration, all parties can be involved regardless of which device they have or where they are," says Francis. "One point on the large assemblies, however, is that mixed reality displays data in context with the environment. If you are in an office building, displaying an entire airplane would not be practical. In this example, VR would be better."

Another area of concern is whether HMDs such as Magic Leap One and smart glasses like HoloLens 2 can support a multiuser experience adequate to satisfy engineers' expectations in design review applications? How do MR systems compare with the VR-based CAVE and powerwall systems? Does the MR collaborative viewing experience for design reviews scale up?

Massive assemblies such as entire airplanes can be modeled and viewed in mixed reality. Designers should note that mixed reality displays data in context with the environment. Displaying an entire airplane in a small office space compromises the effectiveness of the system. Interaction with large assemblies ideally occurs in large viewing areas.

The answer to these questions is: It all depends on the application and the support infrastructure.

"When employed by individual engineers, HMDs provide highly immersive visualization and experiential evaluation of service and assembly requirements during product development and process planning," says Eric Kam, manufacturing business channel marketing and alliances director at the ESI Group. "For buy-off reviews or other gated milestones in an engineering lifecycle, HMDs can make it difficult for teams to participate in virtual reviews. Collaboration between engineers in a common virtual environment, but each using their own HMD stations, is a way to allow collaboration. However, this too has its limits."

That said, a lot of the MR system's performance is determined by its support systems. The number of MR system users able to view the digital product representation or digital twin during a design review depends on the capacity of its network and servers. If these two elements are up to the task, then a distributed development team can often expect a satisfactory experience, regardless of location.

Challenges and Shortcomings

There is no doubt that digital reality technologies in general, and MR systems in particular, have much to offer design engineers. An honest look at the technologies involved indicates that all of the options require improvement.

What's holding these systems back? The tug of war between cost, compute resources and ergonomics tops the list of reasons for the slow adoption rate.

"Existing MR systems do not seem to penetrate far enough into potential low-cost applications, which would drive wider adoption," says Zielinski. "The bulk of applications centers on higher-power, Linux-based systems and have not effectively integrated with the mainstream of lower-cost IoT applications."

Additionally, the number of device types supporting MR points to the fact that the technology still hasn't undergone the shakedown process that culls out unwieldy designs.

"Current hardware solutions are uncomfortable to wear due to where the center of gravity is, weight and in some cases excessive heat," says Theorem Solutions' Francis. "Moreover, many people do not like to wear them because they are neither aesthetically pleasing nor are they able to look at other people without the device impeding their view."

Microsoft considered these shortcomings when it designed HoloLens 2, and aimed to address all of the issues. Only time and the market will tell how successful it was.

As for performance, MR systems face challenges in meeting the high standards of design engineers, specifically in the areas of data handling and presentation.

"To have interaction with the elements overlaid in AR to be useful in an MR context, the latency between the action and a visible result must be low enough to have a meaningful connection between the content and the user," says Zielinski. "This implies that the connected device that we wish to interact with must have a reasonably small communication latency, generally implying reasonable bandwidth, small communications packet size and a processor capable of supporting the application and backhaul infrastructure. This doesn't mean that the processor necessarily has to be more expensive, but the scalability and latency of the architecture has to be considered seriously."

In information presentation, MR systems still wrestle with issues like field of view and resolution. "For operator visibility, if the field of view is too narrow compared to real visibility, then some conclusions from a review might skew in the wrong direction," says ESI Group's Kam.

As for resolution, to correctly address many of the challenges confronting development teams, the visual fidelity and image sharpness need to be very high.

What's Next?

It is likely that MR will follow in the footsteps of VR, carving out a niche in mainstream consumer entertainment systems first, and then using that position in the market as a springboard for design/development, industrial and healthcare applications. At this point, early adopters will move into a second wave of ecosystems as standardized methods become more available. DE

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INFO ➜ **Bresslergroup:** Bresslergroup.com

➜ **ESI Group:** ESI-Group.com

➜ **Microsoft:** Microsoft.com

➜ **Theorem Solutions:** Theorem.com

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Social and Connected PLM

Platforms like Slack and Microsoft Teams are gaining traction, but some say ad hoc exchanges must be part of the record for the digital thread.

BY BETH STACKPOLE

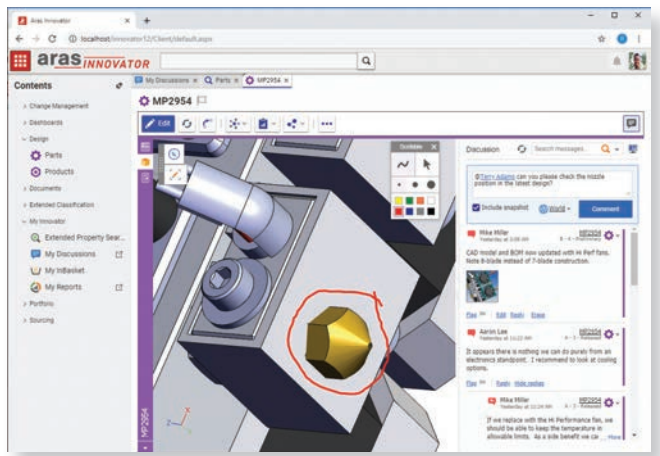
FOR YEARS, EMAIL WAS THE DE FACTO, informal information exchange mechanism for the design team at MBX Systems, a systems integrator providing bespoke computing hardware and software solutions for companies across a host of industries. Sometimes the need was to quickly confer on a product design document or to clarify a question about supplier pricing. In either case, the engineering team was hungry for a way to fire off quick messages to multiple groups, both internally and to outside parties.

"We needed to compartmentalize communications in a way that wasn't just a series of disparate phone calls and emails between person A and B, or person C and D," says Justin Formella, chief strategy officer for MBX. "There were these long email strings that weren't coordinated and weren't necessarily inclusive of all the people who had the relevant information."

MBX found the solution to its communications problem with Slack, a cloud-based collaboration hub, which integrates a range of social capabilities such as instant messaging, the ability to share files, video chats and screen sharing. Slack, along with similar offerings like Microsoft Teams, have become popular enterprise collaboration hubs and are now starting to find their way into software and more recently, hardware engineering circles to help promote more informal interactions among team members.

"Traditional PLM (product lifecycle management) is great at putting together defined digital processes and change management processes, but increasingly, engineering changes are really enterprise changes," notes Peter Thorn, CEO of Cambashi, an analyst and consulting company focused on engineering software and manufacturing. "It's not just engineers looking at the functions of the device, but it's the procurement people thinking about materials and suppliers or manufacturing people considering manufacturing issues. The social element creates a kind of oil that lubricates the process. It's a way people can be integrated in an easy and direct process."

Yet while social collaboration platforms like Slack help advance the product design and development process, they also have the potential to create another siloed information source if not properly integrated or built directly into the core product lifecycle management (PLM) foundation, many experts contend. Ad hoc conversations or informal and impromptu design sessions that take place in a Slack channel without integration with PLM are disconnected from the context of other product-related decisions and also run the risk of being lost or left out of the official product record.

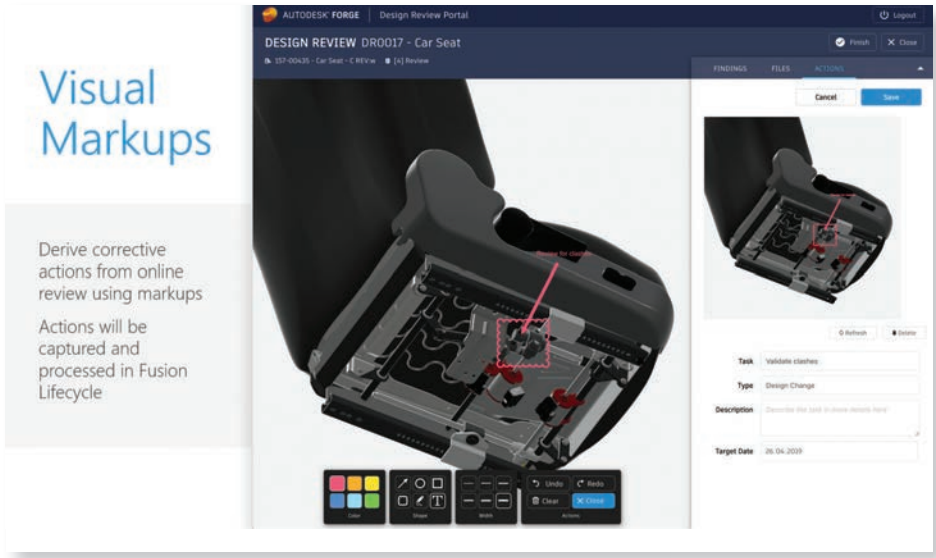


As part of Aras Innovator's Visual Collaboration capabilities, MyDiscussions provides a feed of all activity relevant to the user, including the context in which it was written. ***Image courtesy of Aras.***

"If you're doing ad hoc communication in a disconnected environment, you are collaborating, but you're not capturing what you're collaborating," says Bill Lewis, director of marketing for Teamcenter at Siemens PLM Software. "You don't get the benefits if it's not connected to the PLM system."

Project Communications Channel

At MBX, direct integration into a packaged PLM platform isn't a requirement, thus the company's ability to turn to Slack for their ad hoc communications needs. The company,



Autodesk Forge is intended to enable a light interactive experience that's tracked and managed securely by Fusion Lifecycle. ***Image courtesy of Autodesk.***

given its need to manage hundreds of highly variable bills of materials (BOMs) for clients, opted out of an off-the-shelf PLM approach in favor of building its own sophisticated configuration system, bolstered with Slack, which serves as a centralized communications channel for projects.

Integration with its core enterprise system is accomplished through Slack notifications, which notify engineers when a party needs to sign off on something or if there's a new engineering change request entered into the system.

"Right now it doesn't matter that it's not a core capability of our [configuration management] system," Formella says. "Slack specifically notifies people that they have tasks they need to complete … and lets everyone participate in the context of the specific product they are building."

The downside: There can be information overload if people aren't precise about creating channels and including the appropriate parties. "Sometimes it's like drinking from a fire hose—people participating in many projects will have a lot of information to digest," Formella explains.

Siemens PLM Software is seeing growing demand for social collaboration capabilities from its engineering community in search of flexible and spontaneous communications beyond the prescribed workflows supported by a PLM system, according to Lewis. A survey conducted at its recent user conference pegged adoption of such systems in the ballpark of 20%, Lewis estimates, primarily among software development teams that are actively embracing agile practices.

"The very nature of agile requires software development teams to embrace more ad hoc, flexible collaboration platforms, but it's starting to pick up the pace among hardware development teams as well," Lewis says.

Rather than build its own internal capabilities, Siemens PLM Software is working on a new collaboration service that has integrations between Teamcenter and Slack and Microsoft Teams to be released later this year, Lewis says. The capabilities will work on both ends of the tool chain, allowing users to query Teamcenter PLM from Slack or Teams without leaving the collaboration hub to find out the current status of parts, for example, or to have access to a conversation stream that might be relevant to an engineering change request managed by PLM.

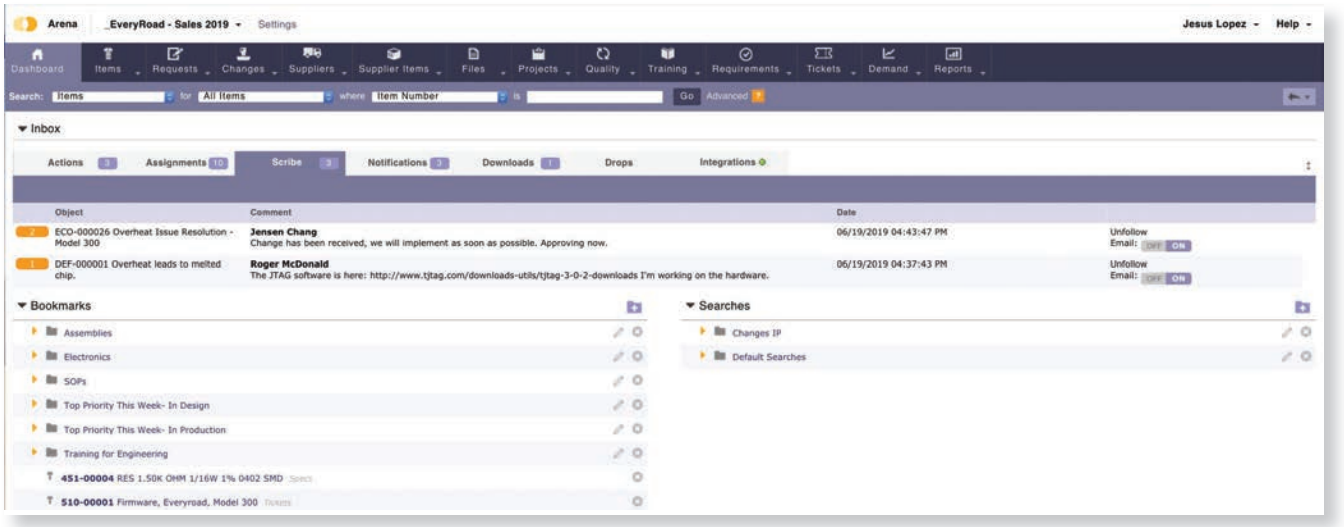
"It will help users make faster decisions with up-to-date information," Lewis says. "A lot of PLM vendors are trying to build their own collaboration capabilities, but from our perspective, that doesn't make a lot of sense."

That's not the case for Dassault Systèmes, which has steadily been folding a number of internally built collaboration capabilities into its 3DEXPERIENCE platform to make product and design collaboration "frictionless" and free from information silos, says Rekha Kamat, 3DEXPERIENCE platform business development executive for the firm. Specifically, Dassault is buttressing the 3DEXPERIENCE platform with social collaboration apps that allow the full spectrum of users to communicate and share ideas in context, with the same access controls and authorizations supported by the enterprise security model—a practice that is not fully embraced by standalone collaboration hubs, she contends.

As part of the 3DEXPERIENCE Social Collaboration Services, Dassault Systèmes offers 3DSWYM, a tool for creating communities to share expertise through blogs and real-time conversations, along with 3DMessaging for instant collaboration and 3DDrive, a way to securely share documents and 3D files in the cloud that is design-aware, so it understands the relationship between linked files. 3DPlay allows design collaborators to experiment with 3D objects, including the ability to drag, rotate or lift models via browser-based visualization.

"This provides a way where communication is contextualized in the same enterprise environment, with the same security model and access controls," Kamat says. "If you want to come back and find out who came up with an idea among a series of stakeholders, you can find it—there's a complete digital thread."

Moreover, users don't have to go back and search for specific conversations—the Social Collaboration Services allow them to subscribe to areas or projects of interest so they will



Arena Scribe's social sharing capabilities ensure casual discussions are not disconnected from the product record. ***Image courtesy of Arena Solutions.***

receive notifications; they can also tag posts, make comments, instant message and invoke video calls and voice chats much like they do with the social platforms used in their personal lives, Kamat says.

At Autodesk, the company is focused on providing its customers with collaboration options. Charlie Candy, global business strategy leader for Design & Manufacturing at Autodesk, says the company equips all of its subscribers with live collaboration tools that enable real-time, visual and interactive feedback to allow them to capture light discussion in context, rather than relying on emails and meetings.

"We want to be flexible to our customer's preferences, so we've made it possible to integrate these platforms with Fusion Lifecycle, using open APIs and Autodesk Forge," Candy says. "For example, a customer could use a Slack integration with Fusion Lifecycle to respond to triggers or updates to records. This provides an event 'watch' that can post messages to social media or Slack (or Trello or Asana) for instance."

Arena Solutions is making it a priority to build its own social collaboration capabilities within its controlled PLM environment. The reason, says Scott Reedy, senior director of marketing, is if you push product development-related data or conversations into a tool like Slack, it requires people to be users of both systems to get the full depth and context for the data.

In contrast, Reedy says Arena Scribe, as part of the PLM foundation, offers one place to manage product development and quality processes collaboratively. Users can engage in discussions through a chat interface, and those interfaces are directly connected to the product record. In addition, there are controls to limit what discussions and comments suppliers may access.

"You need to be able to collaborate with internal teams and supply chain partners, but the key is how do you do it in a secure manner and not like email, which is disconnected," Reedy says. "If the collaboration tool is not directly connected to PLM, it makes it hard for everyone to know if they're working with the latest information."

Aras, which has offered social collaboration capabilities for the Innovator PLM platform since 2014, has continued to round out these functions as part of its HTML5-based Visual Collaboration feature set. Visual Collaboration allows team members to mark up and share 3D models, office documents and schematics as part of a discussion thread that is visible to users in an Innovator side panel displayed in context with a document or BOM, explains Rob McAveney, Aras CTO. Moving forward, McAveney says the tool is being expanded with support for more live sessions, collaboration during authoring and presence indicators for live chat so team members can interact in real time.

In addition to context, Visual Collaboration promotes social interaction with the requisite enterprise security and controls, which McAveney says is critical so engineers don't engage in public discussions about proprietary design intellectual property or reveal competitive information.

"There is a need for informal collaboration—conversations not about what you had for lunch, but about the parameters of the thing you are designing," says McAveney. "That's why we believe it's important to build social into PLM, not because it's cool, but because the information is sensitive and you want to keep control over it." DE

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INFO

- **Aras:** Aras.com
- **Arena Solutions:** ArenaSolutions.com
- **Cambashi:** Cambashi.com
- **Dassault Systèmes:** 3ds.com
- **MBX Systems:** MBX.com
- **Siemens PLM Software:** Siemens.com/PLM

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5G WIRELESS DESIGN CHALLENGES

Image courtesy of Getty Images/Panuwat Sikham.

Evolving wireless standards and the shift to 5G will require multidisciplinary approaches to simulation and design.

BY BRIAN ALBRIGHT

WIRELESS COMMUNICATION IS proliferating across product categories as more devices require multiple types of radios, more types of products and equipment are joining networks via the Internet of Things (IoT), and carriers build out faster 5G networks.

Current wireless standards are increasingly complex, and engineering teams that have to ensure their designs conform to those standards are struggling to keep up. Complicating things is the fact that various design domains involved in these projects (radiofrequency [RF], analog, antenna, digital, software) work in silos, lack a fundamental understanding of the requirements needed for compliance testing in other specialties and don't have access to a shareable modeling platform.

The standards are also constantly evolving. "Staying up to date with the latest version of the standard is important so you can conform," says Roger Nichols, 5G program manager at Keysight Technologies. "It moves pretty fast, so that can be a challenge."

"If you want the best design, you have to stay on top of the standards, or hire somebody else who does," adds Walt Maclay, president of Voler Systems.

The increased use of narrowband is also putting pressure on engineers working in wireless. "Everyone has this demand, and they want to communicate infinitely long distances with very small batteries," Maclay says. "They are designing devices that have to have very low power consumption, but that have to connect directly to the internet."

> **"If you want the best design, you have to stay on top of the standard, or hire someone else who does."**
> – Walt Maclay, Voler Systems

The lack of a unified workflow makes it difficult for teams to efficiently simulate, test and validate designs prior to production. Compounding this issue is the fact that designing for 5G and IoT applications requires more multiphysics modeling.

"The antenna engineers don't know about the smart algorithms that drive the antenna, and the communications people don't know anything about antennas," adds Nick Buris, president of smart antenna design specialist Nebens.

The siloed approach can lead to certification test issues further along in the process. Because transmitters have to follow string standard conformance requirements, companies have to set up tests to replicate what the standards specify. Those companies have to spend a significant amount of money on test equipment that is carefully calibrated to perform the tests.

"The challenge with 5G in particular is that the number of operations and scenarios that have to be accounted for is an order of magnitude greater than LTE," says Ken Karnofsky, senior strategist at MathWorks. "There are a higher number of tests and the number of things that can go wrong is greater."

Additionally, wireless communications are now a part of products and systems that were previously unconnected, so the need for some level of RF expertise is a new requirement for many companies and engineers.

This shift has created an increasing interest in using simulation to identify problems and ensure conformance prior to actually building something and sending it to a test lab or the production line. If problems are found with a product during the conformance testing phase, the cost and complexity of going back and fixing the problem are substantially increased.

Next-Generation System Challenges

Although conformance with most wireless standards can present similar challenges, integrating 5G technology has exacerbated some of these existing problems while creating new issues. 5G uses scalable numerology to support different use cases and services, and this increases the complexity of testing because there are many more possible iterations that must be tested against different use case scenarios. The higher frequencies and wider bandwidths possible in the most recent 5G versions also create a wider array of potential signal impairments.

5G also leverages beam steering techniques at mmWave frequencies, and 5G new radio (NR) systems need to co-exist with other commercial and military wireless networks, while mitigating against potential interference. For some devices, 5G also will result in increased signal-routing complexity and higher antenna bandwidth.

"Antenna design is paramount, especially as you need more antennas and higher frequencies," Buris says. "The design becomes more delicate."

Traditionally, it has been difficult to provide a comprehensive framework for simulating and testing these products because the various component operations have been siloed. The software engineers, digital system engineers, RF and analog specialists all work with different tools in different departments.

"The challenge now with 5G and other standards that are moving to higher frequencies and higher bandwidth is that parts of the system that used to be all analog are done in digital form, or might use digital algorithms to compensate for

some of the nonlinear behavior of the RF system."

Exploring which trade-offs are most effective in engineering and cost requires tools and skills that cut across those boundaries. "The engineers need tools that allow them to consider some aspects and incorporate more insight in the RF/analog part of the system to do their work and know that they are doing it correctly, more so than in the past," Karnofsky says.

> **"This is not rocket science, but it's getting closer."**
> – Roger Nichols, Keysight Technology

An Interdisciplinary Approach

Some tools are emerging to help companies provide a more holistic system outlook to engineers so that they can optimize the entire design—not just the individual components. MathWorks takes a simulation-to-test approach that provides a toolbox for engineers that allows them to put together a single model to help predict system performance.

"The RF engineer, for example, can give an accurate model of what they are designing to the system architect or digital designer, and they can incorporate that into their simulation as they develop their part of the system," Karnofsky says. "They aren't making flawed assumptions."

Nebens offers MIMObit, a simulation tool that allows users to assess the performance of a multiple input/multiple output (MIMO) antenna system at the capacity and throughput level, as well as the dynamic range of communication algorithms with realistic antenna systems. It also helps simulate spectrum sharing, dynamic spectrum access and system coexistence.

Nebens helps make a connection between antenna design and capacity/throughput testing, according to Buris. "Right now, antenna design specifications that people adhere to are based on intermediate performance metrics, but those don't necessarily relate to capacity and throughput," he says. "As a result, they may pass these intermediate tests, but they don't pass the final certification testing. In our tools, we can predict the performance at the throughput and certification test level as they are designing the antenna systems."

At MathWorks, Karnofsky says that the company has developed simplified interfaces so that an RF or antenna engineer, for example, can reference a pared-down version of the digital details of the standard. "They don't need all of the details, just enough details that are relevant to their challenges as an RF engineer," Karnofsky says. "On the digital side, they get every detail on the standard. But there is also a graphical tool that simplifies that down to what an RF or antenna engineer would need to use."

COMSOL also recently released a COMSOL Multiphysics tool so that RF designers can integrate electromagnetic simulations with heat transfer, structural mechanics, fluid flow and simulations. With this tool, designers also can model coupled physics effects as they would occur in a real-world application.

At Keysight, Nichols says that the company emphasizes having solutions that can simulate the entire system, which help reduce design issues reaching the test phase. "It's more of an integrated approach instead of measuring particular stimulus and response approaches," Nichols says. "We have a network emulation system that cannot just make RF measurements, but also make measurements to ensure the entire system works properly."

Keysight has also reduced the complexity of the measurement process and engages in a lot of field training to help users get the information they need quickly.

Buris says more companies will need to shift to this multidisciplinary approach to meet these evolving wireless standards challenges. "With this methodology, you can optimize for the ultimate goal," he says. "That gives you a product that performs better, as well as being smaller and cheaper. The RF and antenna people need to know more about communications, and vice versa. All of the algorithms on the communication side completely oversimplify the antenna systems."

In some cases, companies outsource some element of the design work to a specialist who already has the ability to bridge those different design domains. "We get customers who have done this type of design before, or maybe they do mechanical design but not wireless," Voler's Maclay says. "In some cases they don't want to hire a team and train them, or they are under deadline pressure."

Benefits of a Shared Simulation Environment

Having engineers collaborate or access a shared framework also helps eliminate a common problem in wireless design: over-engineering. When working on assumptions, for example, designers sometimes overcompensate by taking more care than necessary to avoid interference. That adds cost to the finished product. With accurate simulation data from other departments, they can optimize the design more effectively.

"If you overdesign at the intermediate performance specification, it is impossible to get optimized performance and throughput later," Buris says.

This approach also saves time and additional costs by identifying problems prior to the physical testing phase, when it is more expensive to fix any issues.

It also enables design optimization that can result in better products. "A good example in 5G is MIMO technology, which gives you the ability to steer and focus the signal," Karnofsky says. "That requires code design, digital, RF and antenna technologies, and they have to be done all together to optimize across those domains. In addition to getting a cheaper, faster process, you can get a better process through simulation."

Implementing this type of approach takes time and training—a difficult problem in a busy organization. "How do you get people up to speed on something new?" Karnofsky says. "You identify pilot projects and try out new methods so people

can manage the learning curve on a reasonable basis."

Buris goes further, noting that an interdisciplinary approach will require restricting the way engineers are trained from the get-go. "Start at the education system level," Buris says. "The educational system is segmented among mechanical, RF and communications, and that segmentation permeates up to the work environment. You can't really fix it efficiently at the company level without going to the academic level first."

Nichols at Keysight says the company is focused on making simulation and test tools easier to access and use throughout the design process. That includes finding ways to provide visualization for the air testing of millimeter wave systems so that they can understand the results. Keysight is also trying to find ways to make these over-the-air tests more accessible to a wider range of professionals who don't necessarily have deep RF expertise.

"This is not rocket science, but it it's getting closer," Nichols says. "While it's easy to provide that understanding to an RF engineer, it's much more difficult for someone that doesn't have the fundamental understanding of electromagnetic physics. We have to make those things more straightforward."

Software usability and communication will be even more important as more devices are linked to the wireless network via IoT applications. "If your device has a primary function do something other than communicate—like measure or monitor—then how do you bring in that communication piece without affecting the primary function?" Karnofsky asks. "You have to build that in a way that keeps costs down and provides a high battery life. It will get more and more pervasive as other types of engineers need to factor the communication element into their designs. They don't need all of the details of the standard, but need to know the essence and consequences as far as it affects the overall system." DE

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The Rise of Data Science Workstations

NVIDIA's new hardware is making it easier for organizations to process data right on the desktop, as engineers are being drafted into data science roles.

BY RANDALL S. NEWTON

EARLIER THIS YEAR, NVIDIA announced a reference architecture for a new class of professional workstation, the data science workstation. Almost immediately, leading workstation original equipment manufacturers (OEMs) announced workstations that conform to NVIDIA's Data Science specification.

"Data science is one of the fastest growing fields of computer science and impacts every industry," said NVIDIA founder and CEO Jensen Huang at the announcement. "Enterprises are eager to unlock the value of their business data using machine learning and are hiring—at an unprecedented rate—data scientists who require powerful workstations architected specifically for their needs."

An obvious question comes to mind: When are specialized workstations needed? Why not just go with the utility of a typical professional workstation? *Digital Engineering* asked NVIDIA and several workstation vendors.

Their answers repeated a general theme, one we have been hearing from several sources, not just workstation vendors: There is strong and increasing demand for data science in every industry that now uses professional workstations. There are not enough data science specialists to meet employer demand, so engineers and programmers from other disciplines are being drafted as data scientists. This lack of expertise extends to the specifics of what software to run and what computer hardware is best suited for the task.

Specification Defined

A new workstation meeting NVIDIA's standard will have several specific features not common to most existing workstations. The first is dual NVIDIA Quadro RTX graphics processing units (GPUs), based on the Turing GPU architecture. Each Quadro RTX offers up to 96GB of fast local memory, required for large data sets typical of artificial intelligence (AI) training or deep learning and machine learning analysis. The new NVIDIA GV100, a Volta class GPU, also may be used in a data science workstation.

Both the RTX line and the GV100 use two new types of compute cores, RT cores and Tensor cores. RT is short for ray tracing but could also refer to real time; these cores are specialized for high-performance, local visualization.

Tensor Cores specialize in matrix math, common to deep learning and some applications in other fields that now run only on high-performance computing (HPC) clusters or cloud computing platforms. "[Tensor Cores] do the basics for workhorse calculating in deep learning," says Michael Houston, a senior distinguished engineer at NVIDIA.

Tensor cores perform a fused multiply add, where two 4x4 FP16 matrices are multiplied, and the result added to a 4x4 FP16 or FP32 matrix. It sounds like high school math, but tensor cores do millions of these calculations every second, much faster than commodity CPU or GPU compute circuitry. There is also an advantage in the tensor core's ability to accumulate everything in FP32. "Thirty-two bit accumulation tends to really matter for convergence of networks," says Houston, "to make mixed precision really work." Houston says the theoretical performance boost of using tensor cores is 8x. "On a lot of neural nets, NVIDIA sees a 4x speed increase end to end." Data science models often take several days to run; a 4x speed increase would complete a four-day job in one day.

The NVIDIA Data Science Workstation specification calls for Ubuntu Linux 18.04, nicknamed Bionic Beaver, as the operating system. Along with Ubuntu comes a set of software libraries based on the NVIDIA CUDA-X AI protocol for AI research. The collection includes RAPIDS (rapids.ai), TensorFlow (tensorflow.org), PyTorch (pytorch.org) and Caffe (caffe.berkeleyvision.org) open source libraries and several NVIDIA-written acceleration libraries for machine learning, artificial intelligence and deep learning.

The NVIDIA Data Science Workstation specification is primarily used by vendors to create desktop units, but the hardware and software are also available for mobile workstations. *Image courtesy of NVIDIA.*

The department of aeronautics and astronautics at MIT is a pre-release user of the NVIDIA Data Science specification. "The NVIDIA-powered data science workstation provides significant capabilities for training deep neural networks for robot perception. With it, the MIT FAST Labs' ability to train drones to see depth and avoid collisions from a single camera was significantly accelerated because we could process larger batch sizes," says Sertac Karaman, an associate professor in the department.

Workstations meeting the NVIDIA Data Science specification go through testing and optimization tailored to the needs of data science users. The result is a local, single-user computer that NVIDIA says replaces the need for time on more expensive HPC or cloud computing platforms.

"The NVIDIA-powered data science workstation enables our data scientists to run end-to-end data processing pipelines on large datasets faster than ever," said Mike Koelemay, chief data scientist at Lockheed Martin Rotary & Mission Systems. "Leveraging RAPIDS [software libraries] to push more of the data processing pipeline to the GPU reduces model development time, which leads to faster deployment and business insights."

When Money is no Object

"AI is a big market and huge talking point, and it starts on a workstation," says Mike Leach, the workstation portfolio manager for AI, AR and VR at Lenovo. By following the NVIDIA specification, Leach says Lenovo can give users "a certified solution and the right software tools out of the box."

"We see a big shift in data scientists," adds Leach. They start with "gigabytes of data, a data lake of images [or] financial data on the left. They want to move to a fully predictive AI on the right. The journey in-between is seeing the data, iterating on predictions and accuracy."

While attending an AI conference recently, Leach observed "sometimes money is no object." Data scientists are expensive employees to bring aboard, but companies "consider them must-have, and they will provide the right hardware." As a result, Leach says, these scientists "can deliver massive cost savings based on the products they create."

Recognizing the Software Stack

Dell, HP and Microway are also releasing workstations for data scientists that incorporate NVIDIA GPUs. Boutique workstation vendor Velocity Micro is another vendor building workstations to the NVIDIA Data Science specification and

Computex Announcements Reshape Workstations

AMD, Intel and NVIDIA all introduced new technologies and products at the recent Computex trade show in Taiwan that were of interest to workstation users.

AMD announced a significant update to its Zen 2 core, the technology used in its Ryzen and EPYC processors. The company claims the new core runs 15% more instructions per clock cycle than its predecessor, using larger cache sizes and a redesigned floating point engine. The Zen 2 core will power the 3rd Generation AMD Ryzen 9 processor, a new high-end CPU in the Ryzen line designed for workstations. It offers 12 cores/24 threads and is the only CPU or graphics processing unit central processor on the market built with 7nm lithography.

AMD also announced a new motherboard chipset (X570 for socket AM4) that offers the first availability of PCIe 4.0. It claims this generation of PCIe offers 42% faster storage performance than the previous version, and can double motherboard bandwidth compared with the previous version. AMD says it anticipates more than 50 new motherboard models to ship in the next few months from a variety of vendors.

Intel announced its next-generation CPU platform Ice Lake, an integrated heterogeneous computing architecture with enhancements for artificial intelligence and deep learning. The company claims its Intel Deep Learning Boost (DL Boost) addition to the CPU and new AI instructions on the CPU's integrated graphics driver will "usher in a new era of intelligent performance for PCs." Intel claims DL Boost can offer up to 8.8x higher peak AI inference throughput than comparable products. DL Boost AI accelerators will also be available in the Xeon line of workstation and server CPUs. Intel claims common AI workloads such as image recognition and segmentation as well as object detection will run up to 14 times faster than the previous generation of Xeon processors.

NVIDIA announced the launch of new mobile workstations from several vendors using the Quadro RTX line of mobile GPUs. The RTX line for mobile brings the same specs as the desktop line, but in a mobile form factor. It offers real-time photorealistic rendering, AI acceleration and 8K video support for content creation including virtual reality. Dell, HP, Lenovo and MSI were among the vendors with new mobile workstations using the latest RTX technology.

is awaiting formal NVIDIA certification. "We've been doing scientific computers for 20 years, just called different things," notes CEO and founder Randall Copeland.

The biggest change with the NVIDIA Data Science specification is not as much about the GPU as the software stack, Copeland says. "A computer designed to run better for Revit or 3ds Max is not the same as the computer that runs CUDA best."

Copeland says NVIDIA has done a "great job developing a market for artificial intelligence and deep learning." They recognized their CUDA architecture was well-suited for massive data sets, and "they help people who are good in something else who have to become AI experts."

A Personal Data Sandbox

The phrase "data scientist" was first coined by a Google executive in 2010, says NVIDIA's Geoffrey Levene, director of global business development for data science workstations. "Now [the phrase] has caught up to us; data doubles every 18 months in every vertical." From one industry to the next the process is similar, Levene says. Data must be "wrangled," formally known as extract transform load (ETL). "Then you write the code to see what the data can do," he explains.

From the exploration, the data scientist builds a model of the data use case. "This is the training part, used for inference and prediction," Levene says. "Training is time-consuming; inference is fast. ETL is a lengthy process." The workflow usually involved tabular data and "GPUs can accelerate tabular data," he says.

Having a "personal sandbox" for data work is a boon for data scientists, Levene says. "Some are finding they do a week's work in one day with GPU-accelerated workflows." Levene also observes that "98% of AI for product development is machine learning."

Artificial intelligence has been around for a generation, Levene notes, but there wasn't enough data in many industries. Now data is abundant, thanks to both the internet and mobile devices. "Go back a year ago—you either bought time on a cloud GPU or spent up to $500,000 on a system" that took weeks for IT to install, says Levene. "Now you can order a couple of workstations and go to work." DE

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INFO ➜ **Dell:** Dell.com

➜ **Lenovo:** Lenovo.com

➜ **Lockheed Martin Rotary & Mission Systems:** LockheedMartin.com

➜ **NVIDIA:** NVIDIA.com

➜ **Velocity Micro:** VelocityMicro.com

For more information on this topic, visit DigitalEngineering247.com.

The Lenovo ThinkPad P72 comes in a dark gray sculpted case and delivers excellent performance. *Image courtesy of David Cohn.*

Lenovo ThinkPad P72 Displays An Excellent Update

Lenovo's 17-in. mobile workstation delivers great performance at a more affordable price.

BY DAVID COHN

LENOVO RECENTLY SENT US its ThinkPad P72 mobile workstation, the top of its P-series lineup. The ThinkPad P72 is the latest iteration of the company's 17-in. mobile workstation, and is aimed at engineers and designers who run the most demanding applications, want a large screen and need lots of storage. We reviewed the previous generation, the P71, which at the time was Lenovo's only VR-certified ThinkPad (*DE*, May 2018; digitalengineering247.com/r/17658).

Like its predecessor, the Lenovo ThinkPad P72 comes housed in a charcoal gray case made from magnesium and aluminum and wrapped in glass fiber and polyphenylene sulfide. The system measures 16.4x11.1x1.2-in. (about 1/4-in. longer than the P71) and weighs 7.73 lbs. (nearly a half-pound less than the P71). The large 230-watt external power

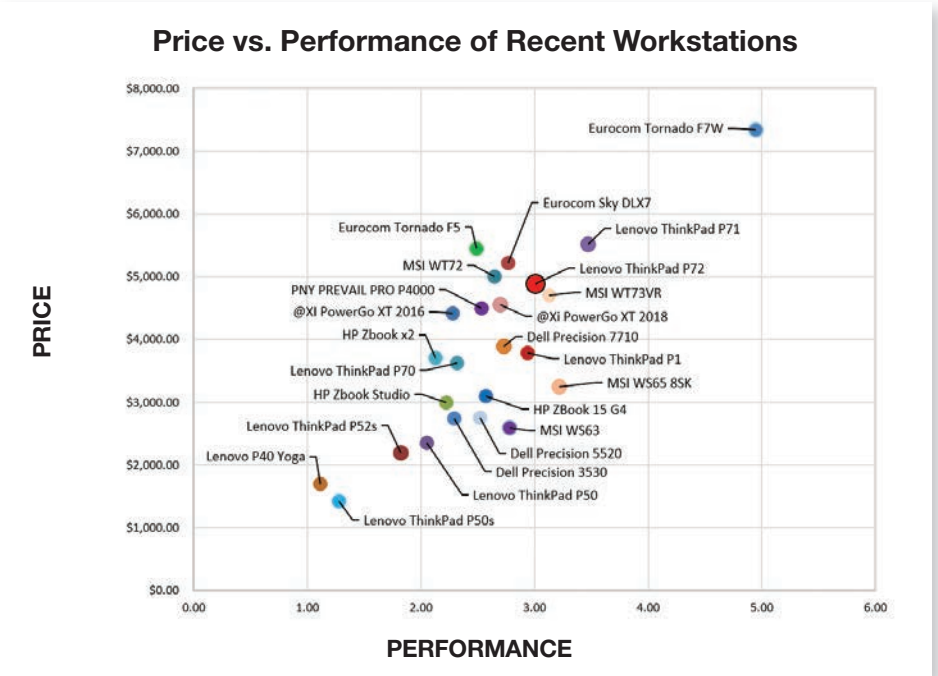
Mobile Workstations Compared

	Lenovo ThinkPad P72 17.3-inch mobile 2.90GHz Intel Xeon E-2186M 6-core CPU, NVIDIA Quadro P5200, 16GB RAM, 500GB NVMe PCIe SSD, 1TB 5400rpm SATA HD	**Origin PC NT-15 Quadro** 15.6-inch mobile 2.20GHz Intel Core i7-8750HJ 6-core CPU, NVIDIA Quadro P4200, 32GB RAM, 1TB NVMe PCIe SSD, 2TB 5400rpm SATA HD	**MSI WS65 8SK** 15.6-inch mobile 2.90GHz Intel Core i9-8950HJ 6-core CPU, NVIDIA Quadro P3200, 32GB RAM, 512GB NVMe PCIe SSD	**Eurocom Tornado F7W** 17.3-inch mobile 3.60GHz Intel Core i9-9900K 8-core CPU, NVIDIA Quadro P5200, 64GB RAM, 500GB NVMe PCIe SSD, 2TB HD	**Lenovo ThinkPad P1** 15.6-inch mobile 2.70GHz Intel Xeon E-2176M 6-core CPU, NVIDIA Quadro P2000, 32GB RAM, 2TB NVMe PCIe SSD	**Dell Precision 3530** 15.6-inch mobile 2.70GHz Intel Xeon E-2176M 6-core CPU, NVIDIA Quadro P600, 32GB RAM, 512GB NVMe PCIe SSD
Price as tested	$4,887	$3,938	$3,249	$7,346	$3,788	$2,738
Date tested	3/26/19	3/11/19	12/12/18	12/12/18	10/24/18	8/28/18
Operating System	Windows 10 Pro 64	Windows 10 Pro 64	Windows 10 Pro 64	Windows 10 Pro 64	Windows 10 Pro 64	Windows 10 Pro 64
SPECviewperf 12 (higher is better)						
catia-04	150.76	108.43	115.38	183.15	64.58	38.67
creo-01	134.45	108.98	97.82	151.79	52.95	42.99
energy-01	17.89	12.39	12.46	20.03	6.50	3.12
maya-04	130.78	75.34	91.69	139.69	41.74	38.42
medical-01	74.81	51.25	60.10	94.74	27.81	12.61
showcase-01	70.52	76.38	61.83	80.91	29.91	19.70
snx-02	185.90	118.76	137.83	214.49	61.50	37.25
sw-03	147.30	124.44	123.80	201.96	76.73	70.59
SPECapc SOLIDWORKS 2015 (higher is better)						
Graphics Composite	4.86	3.80	4.67	5.84	2.58	4.77
Shaded Graphics Sub-Composite	3.18	2.26	2.98	4.03	1.33	3.17
Shaded w/Edges Graphics Sub-Composite	4.01	3.08	3.88	4.99	1.91	4.06
Shaded using RealView Sub-Composite	3.62	2.70	3.37	4.49	1.76	3.59
Shaded w/Edges using RealView Sub-Composite	4.11	3.19	3.89	5.08	2.29	4.07
Shaded using RealView and Shadows Sub-Composite	4.15	3.13	3.87	5.11	2.05	4.10
Shaded with Edges using RealView and Shadows Graphics Sub-Composite	4.34	3.39	4.11	5.28	2.45	4.26
Shaded using RealView and Shadows and Ambient Occlusion Graphics Sub-Composite	12.14	10.11	12.97	13.83	6.35	11.20
Shaded with Edges using RealView and Shadows and Ambient Occlusion Graphics Sub-Composite	11.69	9.80	12.14	13.68	6.87	11.01
Wireframe Graphics Sub-Composite	3.95	3.50	3.69	4.45	3.06	3.85
CPU Composite	3.06	2.78	4.58	3.86	2.85	4.55
SPECwpc v2.0 (higher is better)						
Media and Entertainment	3.58	2.89	3.22	5.15	3.13	2.23
Product Development	3.01	3.05	3.22	4.95	2.94	2.29
Life Sciences	3.62	3.21	3.60	6.19	3.66	2.26
Financial Services	4.38	3.73	4.11	6.16	4.20	3.34
Energy	3.19	5.37	3.56	5.62	5.02	2.28
General Operations	1.38	1.37	1.38	1.96	1.67	1.30
Time						
Autodesk Render Test (in seconds, (lower is better)	42.80	63.80	35.50	34.10	46.40	63.10
Battery Life (in hours:minutes, higher is better)	5:38	4:05	9:01	4:40	7:08	9:26

Numbers in blue indicate best recorded results. Numbers in red indicate worst recorded results.

supply (7.8x3.9x1.0-in.) adds another 2.12 lbs, including its cables.

Raising the lid reveals a 17.3-in. display and 105-key backlit keyboard with separate numeric keypad. As we have come to expect, the excellent, spill-resistant Lenovo keyboard is perhaps the best available in any laptop. Lenovo offers a choice of two in-plane switching matte surface displays—full high definition (1920x1080) or ultra high definition 4K (3840x2160)—neither of which are available as touchscreens. The 4K panel provided in our evaluation unit added $300 to the price. A 720p webcam flanked by a pair of microphones is centered above the display, with an infrared camera to its left.



Price/Performance chart based on SPECwpc Product Development benchmark dataset.

A round power button is located adjacent to the upper-right corner of the numeric keypad while a fingerprint reader is positioned to the lower-left of the keypad, just below the cursor keys. A 4x2.25-in. touchpad with three dedicated buttons is centered below the spacebar. There is also a red pointing stick nestled between the G, H and B keys with its own three buttons directly below the spacebar.

A pair of stereo speakers is concealed beneath a perforated screen just above the keyboard. The caps lock and number lock keys each have their own LEDs as do the function keys dedicated to the speakers and microphone as well as the ESC key, which doubles as FnLock. There are also hard drive activity and Wi-Fi lights located in the hinge area below the center of the display.

Many Choices

The Lenovo ThinkPad P72 is built around one of the latest six-core 8th-generation Intel Core or Xeon Coffee Lake processors. The base Core i7 configuration, which has a starting price of $1,529, comes with a 2.2GHz Intel Core i7-8750H CPU, or you can upgrade to a 2.6GHz Core i7-8850H. The Xeon version of the ThinkPad P72 starts at $2,739 for a system equipped with the 2.7GHz Xeon E-2176M.

Our evaluation unit came with the 2.9GHz Xeon E3-2186M, which added $300 to the price. That CPU has a 12MB SmartCache, a 45-watt thermal design power rating, and a maximum turbo frequency of 4.8GHz.

Although all four available Intel CPUs include Intel HD Graphics P630, every ThinkPad P72 model also includes an NVIDIA Quadro graphics processing unit (GPU). The base Core i7 configuration uses a Quadro P600 with 4GB of memory, or you can opt for an NVIDIA Quadro P2000, which adds $195.

Systems equipped with the Core i7-8850H CPU can also be upgraded to the NVIDIA Quadro P3200 VR-ready graphics card. The base Xeon configuration includes an NVIDIA Quadro P4200 graphics card with 8GB of memory, but systems equipped with the more powerful Xeon CPU (like our evaluation unit) are automatically upgraded to the Quadro P5200 with Max-Q for an additional $965. That GPU includes 16GB of GDDR5 memory and 2,560 compute unified device architecture (CUDA) cores. It has a 256-bit interface and delivers a bandwidth of up to 230GB per second while consuming 150 watts.

The ThinkPad P72 base configurations come with 8GB of DDR4 2400MHz memory, but with four memory sockets, P72 systems can be equipped with up to 128GB of RAM (or 64GB for Xeon-based systems equipped with error-correcting code [ECC] memory). The computer we received came with 16GB of ECC memory (adding $200 to the cost), installed as a single 2400MHz small outline dual-inline memory module.

The P72 supports up to two M.2 solid-state drives (SSDs) as well as a 2.5-in. SATA hard drive. Although the entry-level systems come with just a single 256GB SSD, Lenovo offers M.2 drives with capacities up to 2TB for the primary drive, but oddly limits the second M.2 drive to just 256GB. Our evaluation unit came with both a 512GB Lenovo PCIe NVMe OPAL2.0 M.2 primary drive (a $200 upgrade) and a 1TB Seagate 7200rpm SATA drive (adding an additional $90). A 2TB 5400rpm SATA drive costs just $25 more.

As we have come to expect, the P72 includes lots of connectivity options. The right side provides a combination microphone/headphone audio jack, two USB 3.1 ports, an SD card slot, a mini-DisplayPort connector, a full-size RJ-45 Ethernet jack and a security-lock slot. The left side houses a smart card slot and an always-on USB 3.1 port that can charge USB devices whenever the computer is connected to AC power, even if the system is off. The rear panel provides an additional USB 3.1 port, an HDMI port, a pair of Thunderbolt 3/USB Type-C ports and the connector for the external power supply.

Dual-band Wi-Fi and Bluetooth come standard. Although a six-cell 99Whr battery is the only choice, it kept our ThinkPad P72 running for 5 hours and 38 minutes, about 20 minutes less than the P71. The Lenovo mobile workstation remained cool and quiet throughout our tests, reaching 50dB under heavy compute loads.

Very Good Price/Performance

Lenovo workstations have a history of delivering great performance, and the ThinkPad P72 definitely lived up to that reputation. On the SPECviewperf benchmark, which focuses on graphics, the P72 scored near the top on all the datasets, and did quite well on the SPECapc SolidWorks benchmark.

On the very demanding SPECwpc benchmark, the Lenovo ThinkPad P72 also delivered excellent results, although its storage scores lagged the field just a bit. Independent tests have shown that the M.2 drives currently used by Lenovo do not perform quite as well as the Samsung 970 EVO drives used by other original equipment manufacturers and system integrators. That said, its overall results on this workstation benchmark were still quite good. Its 42.8-second average to complete our AutoCAD rendering beat the previous generation ThinkPad P71, which at the time had set the top mark on this test. But that result falls short of several other mobile systems we've recently reviewed.

ThinkPad P73 Just Announced

Lenovo announced its updated 17-in. mobile workstation, the ThinkPad P73, in June. It is slated to be available later this month.

The 17-in. workhorse in the Lenovo portfolio delivers the largest workspace. Its Dolby Vision 4K UHD screen, designed to maximize the creative space, is suited for multi-window applications and split screen multi-tasking.

The model also delivers top-of-the-stack processing and graphics power with the 9th Gen Intel Xeon and Core processors and up to NVIDIA Quadro 5000 RTX graphics.

The Lenovo ThinkPad P73 will start at $1,849, according to the company.

The base configuration with a Core i7 CPU comes with Windows 10 Home 64-bit, with the upgrade to the Pro version costing $80 more. But all systems based on Xeon processors include Windows 10 Pro for Workstations. The standard warranty covers the system for just one year with depot or carry-in service. Additional coverage is available at the time of purchase that can extend the warranty for up to five years, including accidental damage protection, on-site service and premier support. We boosted the standard warranty to three years for pricing purposes, which added $93.

The ThinkPad P72 is certified for applications from independent software vendors including Autodesk, Bentley, Dassault Systèmes, Nemetschek, PTC and Siemens. You can build a custom configuration via the Lenovo website, where our P72 priced out at $4,887 after an automatic online discount. When coupled with its great performance, that price lands the Lenovo ThinkPad P72 at a very sweet spot in price/performance, making it an ideal choice for those looking for a large mobile workstation. DE

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INFO ➜ Lenovo: Lenovo.com/thinkstation

Lenovo ThinkPad P72

- **Price:** $4,887 as tested ($1,529 base price)
- **Size:** 16.4x11.1x1.2-in. (WxHxD) notebook
- **Weight:** 7.73 lbs. (plus 2.12-lb. external power supply)
- **CPU:** Intel Xeon E3-2186M 2.90GHz 6-core w/ 12MB cache
- **Memory:** 16GB ECC DDR4 at 2400MHz
- **Graphics:** NVIDIA Quadro P5200 w/16GB GDDR5 memory
- **LCD:** 17.3-in. 4K (3840x2160) IPS
- **Hard Disk:** 512GB PCIe NVMe M.2 SSD and 1TB 7200rpm SATA HD
- **Floppy:** None
- **Optical:** None
- **Audio:** Built-in speakers, headphone/microphone jack, built-in microphone array
- **Network:** Integrated Intel 9560 vPro 802.11 AC (2x2) 8265 plus Bluetooth 5.0, one RJ45 gigabit Ethernet port
- **Modem:** None
- **Other:** Four USB 3.1 (one always on), two USB 3.1 Type-C/Thunderbolt 3, mini DisplayPort 1.4, HDMI 2.0, 4-in-1 card reader, 4-in-1 media card slot, 720p webcam, IR camera
- **Keyboard:** Integrated 105-key full-size backlit keyboard with numeric keypad
- **Pointing device:** Integrated touchpad with 3 buttons, pointing stick with 3 buttons, fingerprint reader

Built for Speed

Velocity Micro ProMagix HD60 is a winning workstation at a competitive price.

BY DAVID COHN

LAST YEAR, WE REVIEWED our first-ever workstation from Velocity Micro, the very fast, very expensive ProMagix HD80A (*DE*, July 2018; digitalengineering247.com/r/19009), based on an AMD Ryzen Threadripper CPU. This Richmond, VA-based company, founded in 1992 by a techie and entrepreneur who began assembling custom computer systems to run CAD and other demanding applications, now builds systems for a wide range of uses including gaming, home, office, home theater and driving simulations.

This time around, Velocity Micro sent us its ProMagix HD60, an Intel-based system housed in a charcoal gray mid-tower mATX case measuring 7.25x17.25x17.38 in. (WxDxH) and weighing 23 lbs. The front of the case has an austere appearance, with only the company name and logo etched into the upper portion and a Velocity Micro logo cutout near the bottom.

The power button, a pair of USB 3.1 ports, along with microphone and headphone jacks are located on the top of the case. A pair of fans are also visible below vents on the top of the case. The fans, power button and front panel logo all glow when the system is powered up. Unlike last year's system, however, the ProMagix HD60 ran quiet, averaging 45dB at rest and climbing to just 64dB under heavy compute loads.

The rear of the case provides five additional USB 3.1 ports, a USB 3.1 Type-C connector, an RJ-45 LAN port for the integrated Intel gigabit LAN, antenna connectors for the built-in Wi-Fi, an HDMI port and a DisplayPort connected to the Intel-based graphics, PS/2 mouse and keyboard jacks, an S/PDIF port, and five audio jacks—microphone, line-out/front speaker, line-in/side speaker, rear speaker and center/sub-woofter.

Options, Options, Options

On its website, Velocity Micro lists a starting price of $1,149 for its ProMagix HD60. But the company sells HD60 systems based on both AMD and Intel processors and houses them in either a full or mid-tower case. So, when configuring a system, first choose your CPU and tower options. The mid-tower Intel system is the least expensive starting point.

That case selection gets you an all-aluminum MX3 mATX chassis manufactured by Lian Li, with the power supply mounted

The Velocity Micro ProMagix HD60 is an extremely powerful workstation housed in a simple, mid-tower case. The well-organized interior provides ample room for expansion. ***Images courtesy of David Cohn.***

at the bottom rear. Although the base configuration includes a 500-watt power supply, our evaluation unit came with an 850-watt EVGA SuperNova 80Plus Gold Certified model, able to support power-hungry components. That power supply adds $145 to the base price.

Although the base HD60 configuration includes an ASUS H370M motherboard, the system we received was built around an MSI MPG Z390M Gaming Edge AC motherboard, a $120 option that provides four dual in-line memory module (DIMM) sockets, supporting a maximum of 64GB of non-error correcting code (ECC) unbuffered memory. The base HD60 configuration includes 8GB of DDR4-2666MHz RAM.

Our system came with 32GB, installed using two 16GB Crucial Ballistix memory modules, which added $220 to the price. That motherboard also provides four expansion slots: One PCIe 3.0 x16 slot, one PCIe 3.0 x8 slot, and a pair of PCIe 3.0 x1 slots. An Intel wireless-AC 9560 adapter, which supports 802.11 a/b/g/n/ac plus Bluetooth, is integrated into the MSI motherboard.

The base HD60 system also includes an Intel Core i3-9350K CPU, a four-core 4.0GHz processor. Velocity Micro offers eight other choices, including the eight-core Intel Core i9-9900K that was included in our evaluation unit (adding $475). That Coffee Lake CPU has a base frequency of 3.6GHz and a maximum turbo frequency of 5.0GHz, and a 16MB smart cache. Velocity Micro then overclocked the CPU to 5.2GHz on one core and 5.1GHz on the other seven cores.

The base system also comes with a simple Intel heatsink and a pair of 120mm exhaust fans. But to cool the overclocked CPU in our system, Velocity Micro added a closed-loop liquid cooling system with a 240mm intercooler and a pair of blue-lighted 120mm fans, adding another $155. A similar system without lighted fans is $45 less. The intercooler was mounted to the bottom of the case, drawing intake air through a removable dust filter.

Though all the Intel CPU choices include built-in graphics, the base HD60 configuration includes an NVIDIA Quadro P400 graphics processing unit (GPU). Velocity Micro also offers more than a dozen other graphics cards from NVIDIA, including both Quadro and GeForce boards.

Our evaluation unit came with the new NVIDIA Quadro RTX 6000 GPU. This ultra-high-end board, which added $3,375—considerably less than its $4,000 suggested retail price—is one of the new Turing-based GPUs introduced late last year. The Quadro RTX 6000 provides 4,608 compute unified device architecture (CUDA) cores, 576 Tensor cores and 72 RT cores and 24GB of discrete GDDR6 memory. With a 384-bit interface, the board can deliver a memory bandwidth of up to 672 GB/second, enabling it to achieve 16.3 million single-precision floating point operations per second, to trace as many as 10 billion rays per second and perform real-time ray tracing.

The GPU provides four DisplayPort 4.1 connectors as well as a VirtualLink connector, essentially a USB Type-C port designed to deliver power, display and data to power a virtual reality headset. Since this is a dual-slot board, it blocks access to one of the PCIe x1 slots, and since the board consumes 295 watts, it requires a 14-pin auxiliary power connection.

The base HD60 system also comes with a 250GB solid-state drive (SSD), but here again, Velocity Micro offers lots of choices, including SSDs of up to 2TB, Intel Optane drives up to 960GB, and standard hard drives up to 8TB. The system we received included a 512GB Samsung 970 Pro PCIe NVMe M.2 primary drive (adding $155) and a 2TB 7200rpm Seagate Barracuda 3.5-inch SATA drive ($85). The system can host two M.2 drives plus up to four SATA drives and supports RAID 0 and RAID 1 for M.2 drives and RAID 0, RAID 1, RAID 5 and RAID 10 for SATA drives.

The base system also includes a DVD+/-RW drive. Although the system we received did not include an optical drive, a Velocity Micro representative informed us that they have switched to a modified version of their mid-tower case, the MX4, which will include a front-panel drive bay.

Buy It or Build It Yourself?

Assembling a PC isn't that difficult if you have the parts—it just takes time. And since all the components used by Velocity Micro and other system integrators are readily available, we always wonder if it makes more sense to have someone else assemble the system or if you would be better off doing it yourself. Here's what we found for the ProMagix HD60:

- Mid-tower Lian Li mATX case: $125
- MSI MPG Z390M Gaming Edge AC motherboard: $180
- Intel Core i9-9900K CPU: $500
- Crucial DDR4-2666MHz memory (2 x 16GB): $200
- 850W EVGA Gold Certified power supply: $150
- Cooling Kit: $160
- Samsung 512GB 970 Pro PCIe NVMe M.2 solid-state drive: $160
- Seagate 2TB 7200rpm SATA hard drive: $68
- NVIDIA Quadro RTX6000 graphics card: $4,000
- Windows 10 Professional 64-bit: $200
- Keyboard and mouse: $30

TOTAL: $5,773

Clearly, the NVIDIA Quadro RTX 6000 GPU is the big-ticket item, accounting for nearly 70% of the total cost. But good luck finding one at its $4,000 suggested retail price; those retailers that have them in stock currently charge hundreds more. Since the do-it-yourself price is just a few hundred dollars less than what Velocity Micro is charging for this system (less the extended warranty), having the ProMagix HD60 built for you by trained technicians and backed by an all-inclusive warranty seems like a no-brainer.

Tower Workstations Compared

	Velocity Micro ProMagix HD60 one 3.6GHz Intel Core i9-9900K 8-core CPU over-clocked to 5.1GHz, NVIDIA Quadro RTX6000, 32GB RAM, 512GB SSD, 2TB SATA HD	**@Xi MTower PCIe** one 3.5GHz Intel Core i9-9920X 12-core CPU over-clocked to 4.3GHz, NVIDIA Quadro RTX5000, 32GB RAM, 512GB SSD	**Lenovo ThinkStation P520** one 4.0GHz Intel Xeon W-2125 quad-core CPU, NVIDIA Quadro P4000, 16GB RAM, 512GB SSD	**Dell Precision 7820** two 3.0GHz Intel Xeon Gold 6148 20-core CPU, NVIDIA Quadro P4000, 96GB RAM, 500GB SSD, 2TB SATA HD	**Dell Precision 7920 Rackmount** two 3.0GHz Intel Xeon Gold 6136 12-core CPU, NVIDIA Quadro P5000, 64GB RAM, 1TB SSD, 1TB SATA raid array	**HP Z2 Small Form Factor G4** one 3.8GHz Intel Xeon E-2174G quad-core CPU, NVIDIA Quadro P1000, 32GB RAM, 256GB Z Turbo SSD, 1TB SATA HD
Price as tested	$6,328	$6,400	$2,825	$12,582	$12,702	$1,949
Date tested	4/21/19	2/28/19	7/18/18	7/15/18	7/15/18	8/26/18
Operating System	Windows 10 Home	Windows 10 Home	Windows 10 Home	Windows 10 Home	Windows 10 Home	Windows 10 Pro
SPECviewperf 12 (higher is better)						
3dsmax-05	295.36	230.38	130.05	126.73	137.98	60.53
catia-04	250.89	205.71	157.41	131.31	183.62	62.60
creo-01	203.98	145.05	120.87	88.98	119.95	66.38
energy-01	30.51	22.95	12.76	12.01	16.24	4.46
maya-04	204.77	161.78	122.76	76.95	110.69	53.41
medical-01	127.70	93.89	55.59	52.59	79.75	18.03
showcase-01	191.87	139.17	74.75	80.13	102.97	24.96
snx-02	304.87	309.05	260.35	150.05	210.35	59.36
sw-03	235.54	190.25	180.65	117.99	184.45	103.80
SPECapc SOLIDWORKS 2015 (higher is better)						
Graphics Composite	6.26	5.09	4.55	4.38	4.83	4.17
Shaded Graphics Sub-Composite	4.09	3.40	3.07	2.90	3.28	3.13
Shaded w/Edges Graphics Sub-Composite	5.03	4.26	3.79	3.73	4.11	4.05
Shaded using RealView Sub-Composite	4.64	3.83	3.43	3.27	3.68	3.46
Shaded w/Edges using RealView Sub-Composite	5.24	4.25	3.83	3.85	4.16	3.92
Shaded using RealView and Shadows Sub-Composite	5.33	4.36	3.95	3.71	4.07	3.87
Shaded with Edges using RealView and Shadows Graphics Sub-Composite	5.56	4.47	4.05	4.02	4.34	4.08
Shaded using RealView and Shadows and Ambient Occlusion Graphics Sub-Composite	17.29	13.58	11.50	10.57	12.38	6.03
Shaded with Edges using RealView and Shadows and Ambient Occlusion Graphics Sub-Composite	15.95	12.57	10.93	10.56	11.91	6.75
Wireframe Graphics Sub-Composite	4.61	3.66	3.45	3.25	3.35	3.89
CPU Composite	4.44	4.50	2.95	3.75	4.07	2.53
SPECwpc v2.0 (higher is better)						
Media and Entertainment	6.59	5.92	3.65	5.21	6.27	2.42
Product Development	5.86	5.43	3.09	6.74	6.35	2.24
Life Sciences	7.69	6.43	3.61	10.09	9.93	2.25
Financial Services	6.48	10.75	3.67	24.35	17.73	3.56
Energy	6.28	6.53	1.65	9.31	9.52	2.40
General Operations	2.32	1.90	1.51	1.47	1.86	1.11
Time						
Autodesk Render Test (in seconds, lower is better)	24.10	23.80	61.60	28.30	29.60	45.10

Numbers in blue indicate best recorded results. Numbers in red indicate worst recorded results.

Excellent Performance

With all of its high-end components, including an overclocked eight-core CPU and ultra-high-end GPU, we couldn't wait to put this Velocity Micro workstation to the test. Happily, the ProMagix HD60 lived up to our expectations.

On the SPECviewperf benchmark, which focuses on graphic performance, the ProMagix HD60 turned in the best results we have recorded on all but one dataset, where it finished a close second. On the SPECapc SolidWorks benchmark, the system also performed well.

The same proved true for the very demanding SPECwpc workstation performance benchmark, on which the system garnered the top scores in three of the six test suites representing vertical markets that often have very different computing demands. And on our own AutoCAD rendering test, the 24.1-second average time was just 0.3 seconds behind the record-setting @Xi MTower we recently reviewed.

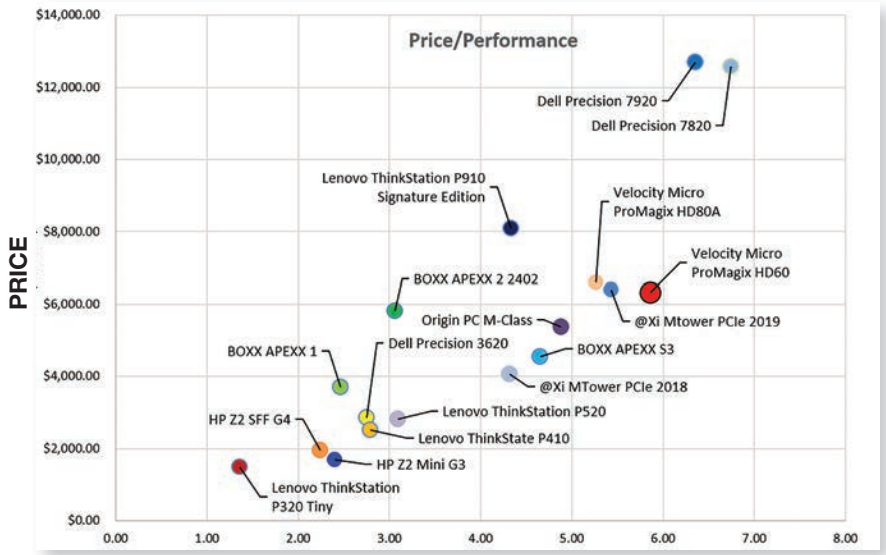
Velocity Micro preloads Windows 10 Home, or you can get Ubuntu Linux for the same price. The Windows 10 Professional 64 pre-installed on our system added $70, or you can save $80 by ordering the system without an OS and install your own. Velocity Micro also does not include a mouse or keyboard unless you specifically add one to your order. You can get various keyboards and mice at the time of purchase. We included a basic Microsoft USB keyboard and optical mouse ($15 each) in our as-tested price.

Although the standard warranty covers the system for one year, the company offers other options. Our as-tested price includes a $299 charge to extend coverage to three years for parts, labor and depot repair service. Velocity Micro also includes a lifetime upgrade plan.

As configured (including the input devices, Windows 10 Pro, NVIDIA Quadro RTX 6000 GPU, and the three-year warranty), our system priced out at $6,328, making it a bit less expensive than other systems we have tested recently, while delivering better performance. Although equipped with certified hardware, the system lacks independent software vendor certification. If that is not an issue for you, Velocity Micro has proven once again that it knows how to assemble a high-end workstation. But this time around, the high price is actually a bargain considering what's included. If you are looking for premier performance, the Velocity Micro ProMagix HD60 is definitely worth considering. DE

David Cohn *is the technical publishing manager at 4D Technologies. He also does consulting and technical writing from his home in Bellingham, WA, and has been benchmarking PCs since 1984. He's a Contributing Editor to* DE *and the author of more than a dozen books. You can contact him via email at david@dscohn.com or visit his website at dscohn.com.*

Price vs. Performance of Recent Workstations



Based on SPECwpc Product Development benchmark dataset.

INFO → Velocity Micro: VelocityMicro.com

Velocity Micro ProMagix HD60 workstation

- **Price:** $6,328 as tested ($1,149 base price)
- **Size:** 7.25x17.25x17.38 in. (WxDxH)
- **Weight:** 23.0 lbs.
- **CPU:** Intel Core i9-9900K (8-core) 3.6GHz w/ 16MB L3 cache overclocked to 5.2GHz single core/5.1GHz all cores
- **Memory:** 32GB DDR4 2666MHz (up to 64GB supported)
- **Graphics:** NVIDIA Quadro RXT6000 w/24GB GDDR6
- **Storage:** Samsung 512GB NVMe M.2 SSD and 2TB 7200rpm 3.5-in. SATA
- **Floppy:** None
- **Optical:** 24X DVD+/-RW
- **Audio:** Onboard integrated high-definition audio (microphone and headphone on top panel; microphone, line-out, line-in, rear, center/subwoofer, and S/PDIF on rear panel)
- **Network:** Integrated Intel I219V Gigabit LAN, Intel wireless-AC 9560, and Bluetooth
- **Modem:** None
- **Other:** Two USB 3.1 Gen 1 on top panel; four USB 3.1 Gen 1, one USB 3.1 Gen 2, one USB 3.1 Gen 2 Type-C, PS/2 mouse and PS/2 keyboard, DisplayPort, and HDMI port on rear panel
- **Keyboard:** None included (optional Microsoft keyboard added to price)
- **Pointing device:** None included (optional Microsoft optical mouse added to price)
- **OS:** Windows 10 Home 64-bit (Windows 10 Professional 64-bit added to price)
- **Warranty:** One-year parts and labor, with depot service and regular business hour support standard (three-year warranty added to price)

BricsCAD Turns on the POWER

BricsCAD V19 extends beyond AutoCAD's capabilities.

BY DAVID COHN

BricsCAD HAS STOOD OUT for many years as a low-cost alternative to AutoCAD, coming from a small privately held company able to devote its attention to a single product. That stature changed last year when Bricsys, its Belgian-based developer, was acquired by Hexagon AB, a publicly traded Swedish company with more than 19,000 employees and revenue of more than $4 billion (compared to Autodesk's 9,000 employees and $2.57 billion revenue for fiscal 2019).

Although BricsCAD development remains based in Ghent, Belgium, the acquisition gives Hexagon an end-to-end platform from conceptual design to building information modeling (BIM) to construction execution and reality capture. But BricsCAD is also a great tool for general CAD and mechanical design.

Bricsys was founded in 2002. Early versions of BricsCAD were essentially rebranded releases of IntelliCAD, an early AutoCAD workalike. But after acquiring intellectual property from the Russian software company LEDAS, Bricsys went on to rewrite BricsCAD using its own code. As a founding member of the Open Drawing Alliance (ODA), much of the Bricsys code is now also available for use by other ODA member companies.

BricsCAD uses DWG as its native file format for 2D drafting and 3D modeling. Although BricsCAD duplicates most AutoCAD features, it then goes well beyond AutoCAD by serving as a platform for BIM and mechanical product design.

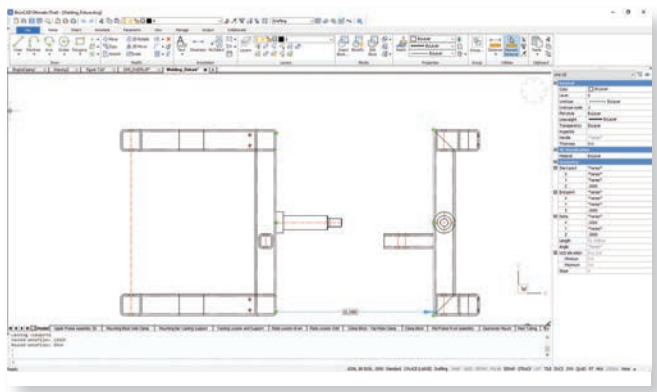
The program is available for Windows, MacOS and Linux and features near-complete compatibility with AutoCAD, including scripts, menus, LISP routines and customizations. There is also an active developer network with hundreds of add-on programs available.

Chameleon-Like Interface

Although BricsCAD is an AutoCAD workalike, it isn't a look-alike. When you first start the program (in its Drafting workspace), the interface consists of a Menu bar across the top of the screen, with an Access toolbar (similar to AutoCAD's Quick Access toolbar) and a ribbon docked below.

Like AutoCAD, each open drawing has its own document tab across the top of the drawing area, which you can use to easily switch between drawings. Tabs at the bottom of each drawing let you switch between Model space and various layouts. A Properties panel is docked to the right of the drawing window. There is also a docked command window, just like AutoCAD, and a Status bar across the bottom of the screen.

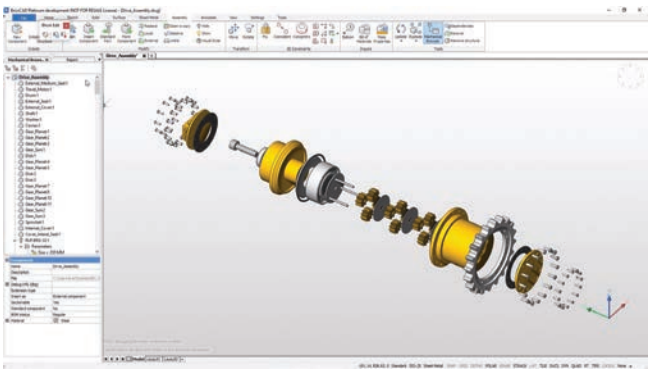
But the interface is chameleon-like. When you switch to the Modeling workspace, the ribbon is replaced by pull-down menus and toolbars, reminiscent of AutoCAD 2008. Switch to the Mechanical workspace, and you're back to using a ribbon. Switch to the BIM workspace and the interface includes pull-down menus and a non-changing ribbon-like band of frequently used tools.



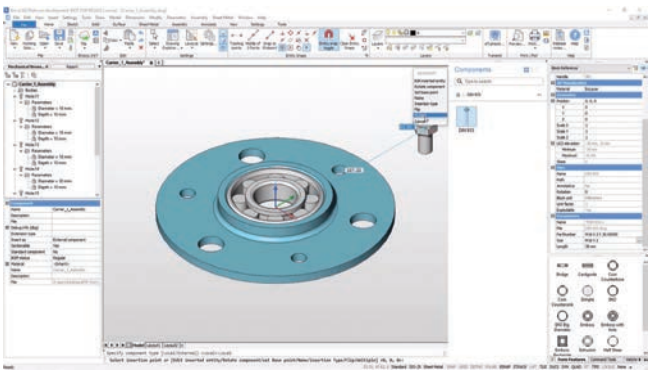
The BricsCAD interface varies depending on the current workspace. The new nearest distance tool lets you view and modify distances between two selected entities. ***Images courtesy of David Cohn.***

Within the drawing window, a user coordinate system (UCS) icon is typically located in the lower left and a Look From widget (similar in function to AutoCAD's ViewCube) appears in the upper right. Most commands are the same as AutoCAD. For example, you can start the Line command from the ribbon, from a menu or by typing the command name or a shortcut (the same as aliases in AutoCAD), although instead of accessing command options in the command line or by right-clicking, you must type or choose the option from a prompt menu that initially pops up in the upper-right corner of the drawing.

Another user interface feature unique to BricsCAD is the Quad cursor menu, a panel that provides a grip-editing alternative. When you hover over an object, the Quad cursor reports information about it and, when appropriate, displays commands to modify the object. If no command is active, when you right-click in a blank spot, the Quad cursor presents commands that you would most likely use. Like most aspects of BricsCAD, the Quad cursor can be customized to change its behavior and appearance.



Tools in BricsCAD Mechanical let you create associative exploded representations of assemblies.



Parametric parts chosen from a library of 30,000 objects can be inserted by dragging and dropping from the Components panel and then modified by adjusting parameters.

Beyond AutoCAD

Although BricsCAD doesn't include every function found in AutoCAD, the list of missing features is shrinking. For example, BricsCAD V19 adds a Block Editor, a dedicated environment for creating and editing blocks.

While working in this environment, you see only the objects that are part of the block, but the capabilities are much different from AutoCAD. For example, to create a parametric block in BricsCAD (analogous to a dynamic block in AutoCAD), you must add parameters to the block, save the block as a separate drawing and then insert it using the BIMINSERT command. Once inserted, you can select an instance of the block and then use fields in the Properties panel to adjust parameters.

These differences can affect compatibility. When you open a drawing created with AutoCAD that includes dynamic blocks, those blocks function in BricsCAD just as they do in AutoCAD, but you cannot edit the blocks in BricsCAD.

When you open a BricsCAD drawing in AutoCAD, however, parametric blocks lack their parametric capabilities and cannot be modified using AutoCAD's block editor, but upon reopening the drawing in BricsCAD, those blocks are once again parametric.

In other respects, BricsCAD goes beyond AutoCAD's capabilities. A perfect example is the new Blockify tool, which searches the drawing for an identical set of entities and replaces them with block references. Also new to BricsCAD V19 is a PDF Import command that lets you import geometry from a PDF file, similar to the function added to AutoCAD 2017.

Like that release of AutoCAD, the new tool in BricsCAD does fine converting TrueType text into MTEXT. But, since the PDF format doesn't recognize AutoCAD SHX fonts, text that had originally been defined with SHX fonts is stored in the PDF file as geometry. When that PDF file is imported, the SHX text becomes polyline geometry. AutoCAD 2018 solved this problem by introducing a text recognition tool that converts the geometry representing text back into actual text objects. Unfortunately, BricsCAD does not yet include that capability.

Other New Features

BricsCAD V19 also adds an improved dimensioning tool that lets you apply multiple types of dimensions using a single command, similar to functionality introduced in AutoCAD 2016. But the new Nearest Distance function is unique to BricsCAD. When you select one entity and then select another, the program displays the shortest distance between them. You can then move the second entity in relation to the first by simply changing the dimension.

The new release also introduces Adaptive Grid Snap, which lets you manipulate objects using concise values without keyboard entry. After moving the cursor over an object, you press and hold the left mouse button to display a Manipulator widget. When you move the cursor over one of the widget's axes and press the left mouse button again, the program displays a dynamic ruler. You can then move the object using the ruler. The ruler resolution adapts based on the current zoom factor.

New data linking tools let you link data from an Excel spreadsheet directly into a table within the drawing. Once you have established a link, any changes you make in the linked Excel spreadsheet are automatically pushed to the table in the BricsCAD drawing.

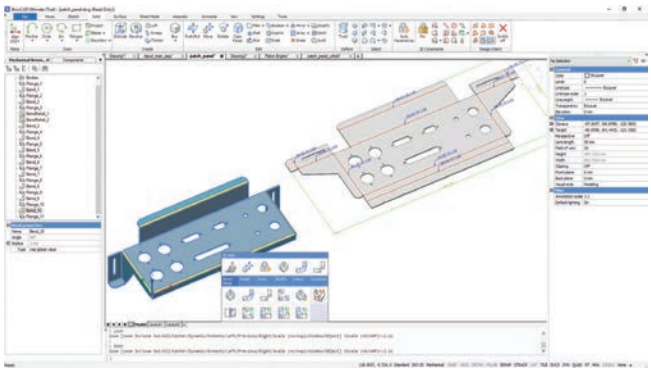
Advanced Mechanical Capabilities

Over the past few releases, Bricsys has been enhancing the program's BIM and mechanical design capabilities. For *DE* readers, we focused almost exclusively on the mechanical tools. BricsCAD Mechanical now includes a library of 30,000 parametric parts. These individual drawing files can be inserted as blocks by dragging and dropping them from the Components panel and then modified by adjusting parameters in the Properties panel.

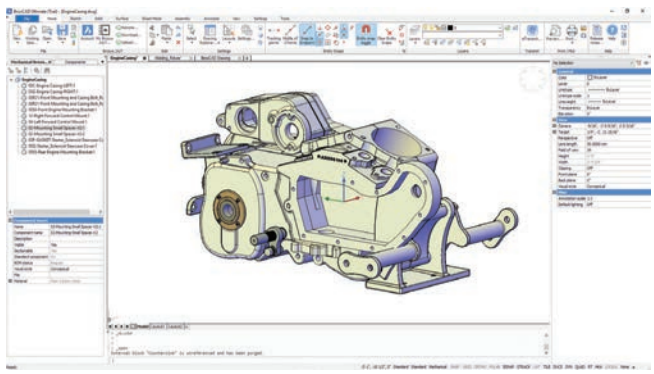
Users can also create associative exploded representations of assemblies without modifying the assembly. Exploded representations are stored as dedicated blocks. Each part in an exploded representation is linked with the corresponding part in the assembly. Exploded views can contain one or several steps.

You can animate steps, generate drawing views of the exploded representation and place balloon annotations on corresponding drawing views. New in V19 is the ability to automatically constrain and parameterize solid models in a single operation. And again, BricsCAD goes beyond AutoCAD in its ability to apply constraints in 3D and 2D.

BricsCAD Mechanical also incorporates some rather sophisticated sheet metal capabilities, including the ability to model



BricsCAD Mechanical includes sophisticated sheet metal capabilities. The Quad cursor, unique to BricsCAD, provides an alternative to grip-editing.



Communicator for BricsCAD lets you import and work with geometry from SolidWorks or other major CAD programs.

sheet metal parts and generate their unfolded representations, complete with manufacturing information. With the addition of Communicator for BricsCAD ($715), a separate import/export module, you can work with geometry and product and manufacturing information data from most major CAD programs.

Low-Cost Licensing Options

Unlike AutoCAD, BricsCAD does not require a subscription. You can buy it once and it's yours to use forever, although for a yearly fee you gain access to priority support and free upgrades. Bricsys also offers annual subscriptions as well as volume pricing and network licenses.

The company sells three editions of BricsCAD. BricsCAD Classic ($826) provides basic 2D and 3D CAD capabilities and includes the full power of LISP customization. BricsCAD Pro ($1,105) includes all the Classic features and adds full customization support (including VBA, ARX and .NET support, opening up access to hundreds of third-party applications) and 3D direct modeling, as well as rendering, materials and lighting. BricsCAD Platinum ($1,560) includes all the Pro features and adds freeform 3D modeling, 2D and 3D constraints and assembly modeling.

Bricsys also sells BricsCAD Mechanical ($2,275), which adds bills of materials (BOMs), assembly mass properties, exploded views and sheet metal design; BricsCAD BIM ($2,405), which provides building information modeling tools including HVAC and structural modeling, and quantity takeoffs; or BricsCAD Ultimate ($2,646), which includes all of the Platinum features plus BricsCAD BIM and BricsCAD Mechanical.

You can download a free trial of BricsCAD to try the Ultimate edition for 31 days. A trial of Communicator is also available as a separate download. During the trial, you can set your copy of BricsCAD to run as any of the available products (Classic, Pro, Platinum, Mechanical, BIM or Communicator) so you can see which feature set is best for you. Bricsys also offers Bricsys 24/7, an online project collaboration tool (with annual prices based on the amount of cloud-based storage needed), and BricsCAD Shape, a free conceptual modeling tool.

BricsCAD help and tutorials are available online, although most tutorials are simply videos showing a particular function without the benefit of sample files or step-by-step instructions, which can make learning the program's more advanced features a bit challenging. There is also an extensive eBook, "BricsCAD for AutoCAD Users," that covers most of the program's capabilities, explaining them from the perspective of someone who already knows how to use AutoCAD.

BricsCAD provides a lot of power at a fraction of the cost of AutoCAD. It then goes beyond AutoCAD's native capabilities. Whether you're looking for an affordable DWG-based alternative to AutoCAD or a full-blown BIM or mechanical modeling program, BricsCAD deserves serious consideration. DE

David Cohn *is the senior content manager at 4D Technologies. He also does consulting and technical writing from his home in Bellingham, WA. He is a Contributing Editor to* DE *and has authored more than a dozen books. Contact him via email at david@dscohn.com or visit dscohn.com.*

INFO ➜ Bricsys: Bricsys.com

PRICING

(PERPETUAL LICENSE INCLUDES 1-YEAR MAINTENANCE)

- **BricsCAD Classic:** $826 perpetual license or $330 1-year rental subscription
- **BricsCAD Pro:** $1,105 perpetual license or $442 1-year rental subscription
- **BricsCAD Platinum:** $1,560 perpetual license or $624 1-year rental subscription
- **BricsCAD Mechanical:** $2,275 perpetual license or $910 1-year rental subscription
- **BricsCAD BIM:** $2,405 perpetual license or $962 1-year rental subscription
- **BricsCAD Ultimate:** $2,646 perpetual license or $1,058 1-year rental subscription
- **Communicator for BricsCAD:** $715 perpetual license or $286 1-year rental subscription

MINIMUM SYSTEM REQUIREMENTS

- **OS:** Windows 10, Windows 8/8.1, Windows 7, Windows Vista SP2, Windows Server 2008 R2, Mac OSX 10.0 or higher, Linux (Ubuntu 14.04 or higher, openSUSE, Fedora)
- **Processor:** 1GHz processor or faster
- **RAM:** Windows: 256MB plus RAM required by OS, Mac: 1GB
- **HD:** 250MB for install plus 1GB or more free space
- **Display:** 1024x768 with TrueColor
- **GPU:** Any graphics board from AMD, Intel, or NVIDIA capable of XGA resolution

Cloud-Based CAD Platform Offers Access Anywhere

Onshape's latest features focus on performance, integration and usability.

BY DAVID COHN

BY NOW, MOST *Digital Engineering* readers have heard of Onshape. Developed by many of the same people who originally created SolidWorks, Onshape is a full parametric platform that incorporates 3D part and assembly modeling, associative 2D drawings and data management combined with sharing and collaboration, version control, release management and tools that enable users to create custom features.

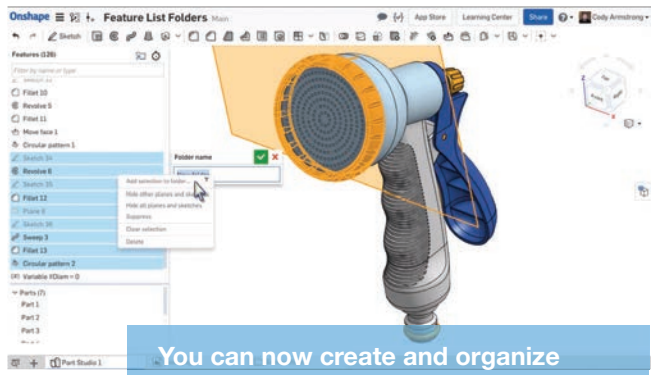
But unlike most CAD programs, both the Onshape software and your CAD data reside in the cloud. That means anyone anywhere in the world can access the same system at any time using any device. On a computer, Onshape runs in a web browser. There is no software to install. You simply go to the Onshape website, log in and go to work. Any projects you already started or that have been shared with you are immediately available. For Android or iOS tablets and phones, after installing the app, you have access to nearly the same functionality as the browser version.

Because the software runs in the cloud, there are no downloads, license keys, service packs or compatibility concerns. Everyone always has the latest version of the software. And since projects are stored in the cloud, there are no files to download and there is no need to check in or check out files like in a traditional product data management system. Anyone on the design team can access projects anywhere, any time. Administrators can adjust access privileges so you retain control over your work, and you can immediately see who changed what and when it was changed.

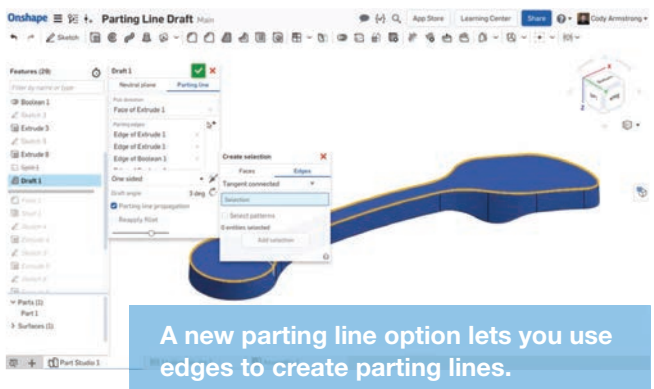
A Host of Improvements

Because the software lives entirely online and every customer is always on the latest release, the company rolls out updates on a nearly monthly basis. Since we last reviewed Onshape (*DE* June 2018; digitalengineering247.com/article/cad-gets-in-shape), the program has gained hundreds of new features and capabilities. For example, you can now create and organize features in a feature list folder. Features can be reordered within the folder and the folder can be reordered within the feature list. You can also now filter the feature list based on part, type, or name and filter a folder to reveal only the features within a folder of that name.

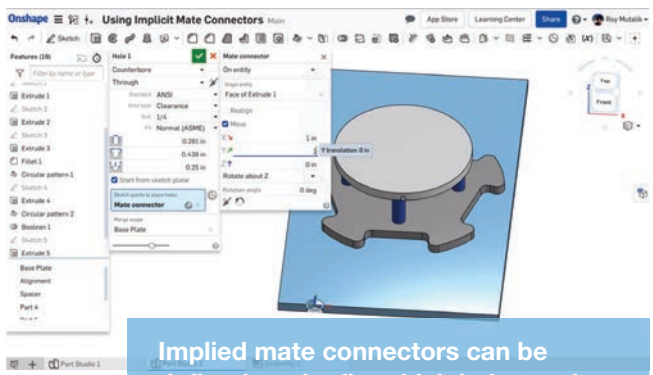
You are no longer limited to applying draft along a plane or planar face. A new parting line option lets you define the pull



You can now create and organize Onshape features in a feature list folder. *Images courtesy of David Cohn.*



A new parting line option lets you use edges to create parting lines.



Implied mate connectors can be defined on the fly, which is faster than first defining a sketch and a vertex reference.

direction and parting edges, and you can even add draft in two directions. If a new intermediate profile is added after creating a loft, rather than having to delete and reselect the profiles, you can now simply add the new profile and reorder the profiles. Plus you now have a new option to view the curvature combs of previewed edges while creating a feature, with curvature combs updating dynamically as you modify the curves.

Onshape has long been able to use explicitly created mate connectors as a reference for transforms, as well as creating holes and other features. You can now define and use implied mate connectors on the fly. For example, you can revolve a sketch about an axis defined by the origin or a sketch line. Or, create a hole by defining an implicit mate connector at the corner of a part and then translate the mate connector by specifying appropriate offsets, which is faster than defining a sketch and a vertex reference.

Assembly and Sheet Metal Enhancements

Last year, Onshape added multiple independent inputs to allow for multiple part configurations instead of listing every design permutation in one large table. That same approach is now available for assemblies as well. You can choose the type of input—list, checkbox or configuration variable—and then configure assembly features that respond to those inputs so that changes to the input values yield different assembly configurations.

Onshape is also unique in that you can work simultaneously in both the folded and flat view. As a result, you can create sketches and features directly in either view and the features you add to the flat view and the bend view of the model appear in the same feature tree, without any extra folding or unfolding steps.

You can also now create hems using a new dedicated sheet metal feature, with options to define a straight, rolled or teardrop hem, and to specify its inner radius and total length.

Drawing Improvements

Onshape callouts use the item number from the bill of materials (BOM) table to populate the text in each balloon. These item numbers are linked to the BOM and update automatically if the table order is changed or parts are added or removed. You can also now add text above, below or to either side of the callout, and also include part properties and table properties.

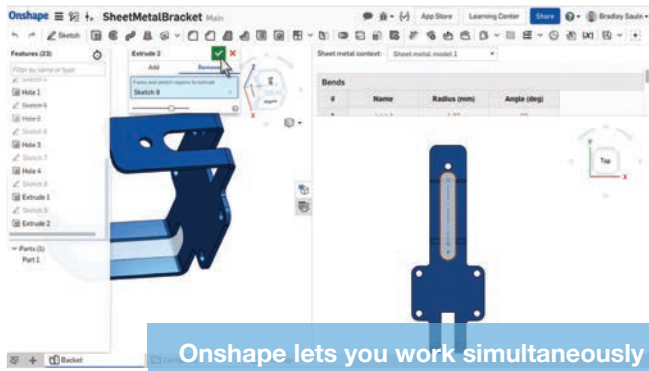
Dimensions and annotations, including hole callouts, now snap to alignment lines, making it much easier to organize drawings. You can also add leaders to geometric dimensioning and tolerancing (GD&T) frames and add multiple leaders to weld and surface finish symbols.

Ordinate dimensions have seen significant improvements. Jogs are now automatically created to avoid overlapping other dimensions. If you accidentally create a jog, you can simply drag-and-drop the dimension to remove it.

You can now define the depth of section views in Onshape drawings, setting a blind value or selecting a point on the view as a reference for the depth. There is also a new dimension tool for chamfer features, with the ability to add an optional prefix.

You can also split a BOM in an Onshape drawing and then drag the portion of the BOM below the break to reposition it. If necessary, you can split the BOM multiple times and split portions can even be moved to a different sheet in the drawing. And finally, when changes are made to an Onshape drawing template, you can easily update the title block and border in an existing drawing without disturbing views that have already been created.

With Onshape's ability to configure multiple independent inputs now extended to assemblies, you can build an infinite number of assembly configurations with just a few inputs.



Onshape lets you work simultaneously in the folded and flat view.

Performance and Usability Updates

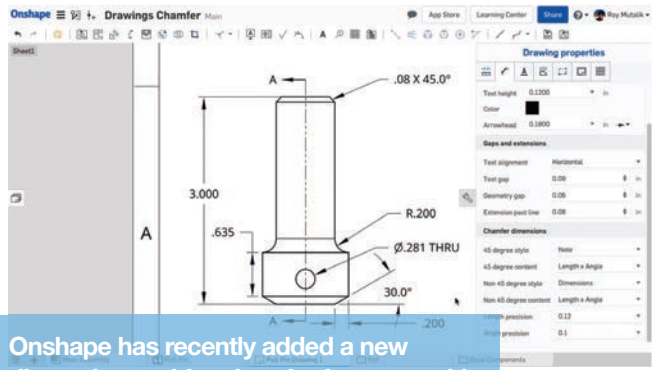
Performance has been improved, particularly when working with large assemblies and complex views. Onshape has added integration with Google Drive and Dropbox, so you can browse for files from within Onshape. You can also import, export and search within those connected services. Additionally, Onshape remembers the last location that was imported from or exported to within a connected cloud service.

In the past, if one user switched to a different configuration, all users accessing that document would also be switched. Now, users can change configurations independently in both parts and assemblies. However, if you enable follow mode, the configuration changes will sync with the user you are following. In addition, link sharing is specific to the configuration that is active when the link is copied. So, even if the configuration is changed after sharing the link, the user that follows a link will see the document open at the configuration you had intended.

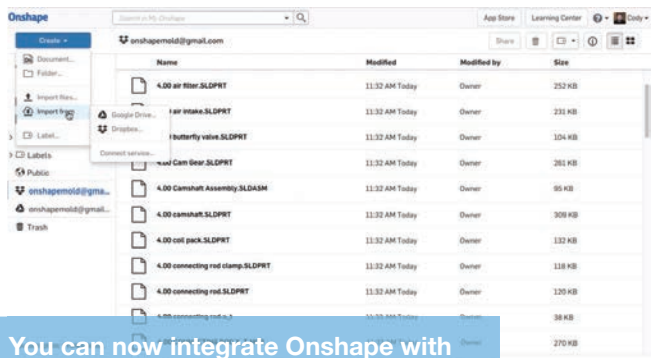
Measuring the distance to or from the origin is now as easy as selecting the reference and picking the origin, with the result shown in the lower-right corner. In addition, when you select faces, the program now shows the total area of all faces selected.

Standard PEM fasteners have been added to Onshape's library and are available when creating holes using the hole feature tool.

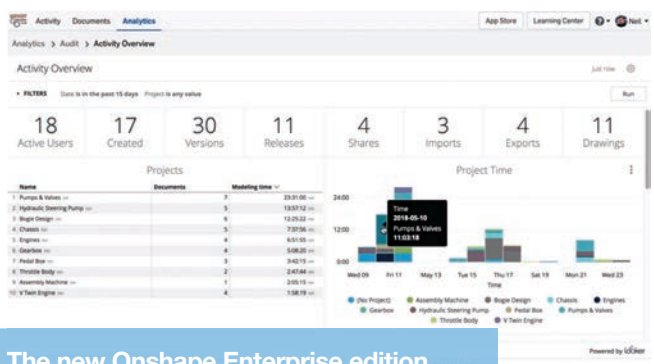
Finally, when someone opens a document and they have view-only permission, they now see a special view-only toolbar near the bottom of the screen. This toolbar helps non-CAD users navigate within the model without having to spend a lot of time learning Onshape. You can even display the configuration panel, making it easy for anyone to build configurations on the fly. You can add comments and upload images to comments, follow others in the document, export and print as well as measure and obtain mass properties.



Onshape has recently added a new dimension tool for chamfer features, with the ability to include an optional prefix.



You can now integrate Onshape with Google Drive and Dropbox.



The new Onshape Enterprise edition adds dashboards with real-time analytics, project-based activity tracking and role-based access control.

New Enterprise Edition

There are now five ways to use Onshape. A free version enables anyone willing to share their designs to sign up for an account and immediately begin using the software.

For students and educators, Onshape's free Education Plan lets students log in from home or school and collaborate together in real time. The Standard version ($1,500 per year) includes part and assembly modeling and drawings. The Professional version ($2,100 per year) adds formal release management, approval workflows and notifications, complete data management, custom properties and metadata, and company-level administration tools. Users can collaborate with any other Onshape user, regardless of their plan (assuming they have access permission), but free plan users cannot edit private documents (even if the sharer has given them editing permission).

Last summer, the company launched a premium Enterprise edition, which adds real-time analytics and dashboards; project-based activity, reporting and audit trails; centralized intellectual property control; role-based access control; and project-specific workflow settings. An Enterprise subscription starts at $20,000 per year; companies can provision their users with a mix of full user licenses ($3,000 per user) or light user licenses ($300 per user) to reach the $20,000 minimum.

Because Onshape runs in a browser, a powerful workstation and a discrete graphics card are not required, although the program does perform better on systems equipped with a separate graphics processing unit (GPU) as long as the computer uses it when running the web browser.

Over the past year, Onshape has gained even more power, proving itself as a robust alternative to expensive software running on expensive hardware. It is suited for single users, small teams and now—with the advent of the new Enterprise version—large manufacturers. DE

David Cohn *is the senior content manager at 4D Technologies. He also does consulting and technical writing from his home in Bellingham, WA. He is a Contributing Editor to* Digital Engineering *and is the author of more than a dozen books. You can contact him via email at david@dscohn.com or visit his website at dscohn.com.*

INFO → Onshape: Onshape.com

PRICING:

- **Onshape Free:** Free to anyone
- **Onshape Education:** Free for students and educators
- **Onshape Standard:** $1,500 per user per year
- **Onshape Professional:** $2,100 per user per year
- **Onshape Enterprise:** $20,000 minimum per year

SYSTEM REQUIREMENTS

- **Any computer with a compatible web browser:**
  - Google Chrome, Mozilla Firefox, Safari (Mac OS only) and Opera. Microsoft Edge and Internet Explorer are currently not supported.
- **Onshape is also available as an Android app or an iOS app:**
  - **Android:** requires Android 4.4 or higher
  - **iOS:** requires iOS 10.0 or later

Next-Gen Engineers

Student Design Competition Profile: Chem-E-Car Competition

Constructing Cars Powered by Chemical Energy

BY JIM ROMEO

THE AMERICAN INSTITUTE of Chemical Engineers (AIChE) sponsors an annual Chem-E-Car Competition to promote learning and professional development for chemical engineering undergraduates. Scott Fogler at the University of Michigan founded the competition in 1999 with the help of the AIChE Student Chapters Committee.

The Chem-E-Car Competition challenges students to design a vehicle's power and stopping mechanism via chemical reaction. ***Image courtesy of AIChE.***

Since then, the Chem-E-Car Competition has grown to engage nearly 200 teams—or over 1,000 Chemical Engineering Students—around the world at over a dozen regional competitions held annually. The top qualifying teams from each region compete every year at AIChE's Annual Student Conference.

To learn more about this competition, we spoke to Sarah Ewing, a senior membership associate with AIChE.

Digital Engineering: What is the intent of the competition?

Sarah Ewing: The purpose of AIChE's Chem-E-Car Competition is to provide chemical engineering undergraduate students with an opportunity to apply their knowledge by designing and constructing a car powered by a chemical energy source that will safely carry a specified load over a given distance and stop. This competition also increases awareness of the chemical engineering discipline and safety principles.

DE: Can you tell us about some of the designs that are part of the event?

Ewing: Each Chem-E-Car team must design a power source as well as a stopping mechanism in order to control the distance traveled. The chemical reactions that are used to power and stop the vehicle are up to the students. Some commonly used power sources include electrochemical batteries (lead acid, galvanic cell, aluminum air or hydrogen fuel cell) or thermoelectric generators.

The most popular stopping mechanism for the Chem-E-Car Competition is the Iodine Clock Reaction, which involves mixing a form of iodine, redox reagent and starch. When these initially colorless solutions are mixed, they will eventually turn to a dark blue. This color-changing reaction will block light coming into a light sensor, which cuts the power to the motor and signals the car to stop.

One hour prior to the competition start time, Chem-E-Car teams are given a target distance, which ranges from 15 to 30 meters and a "water weight" that must be carried on the vehicle, which can range from 0 to 500 milliliters. This is when the real challenge begins, because each team must properly calibrate their stopping mechanism in order for the car to stop as close to the target distance as possible.

DE: Anything else you'd like to tell us about the event?

Ewing: AIChE is very proud of its Chem-E-Car Competition Safety Program, which was developed to ensure the safe preparation and operation of vehicles during all phases of the competition, including construction, testing and the competition. The safety program also instills the importance of process safety principles to future generations of chemical engineers. Each Chem-E-Car team must prepare an Engineering Design Package (EDP) and pass an in-person safety audit before they are permitted to compete in the event. This safety audit provides students with valuable real-world process safety experience before they enter the workforce. DE

MORE ➜ aiche.org/community/students/chem-e-car

Jim Romeo *is a freelance writer based in Chesapeake, VA.*

Advertiser Index

| COMMENTARY |

By Vincent Mazur

Why BOM Management Matters

THE WORST TIME to find out that a two-cent part or any of its substitutes isn't available is after the product has been sent for manufacturing. The business impact can be substantial in most cases, if not disastrous.

Late product introductions, delayed marketing programs and wasted time are only some of the negative consequences of a problem that is largely preventable with more proactive bill of materials (BOM) management practices.

Electronic components are foundational to electronic designs. However, designers that choose them also inherit characteristics largely beyond their control, including availability, cost, lifecycle, performance-to-datasheet, authenticity, quality and reliability, which represent touchpoints of risk. Combine this with component markets fluctuating in real time, and the increasing impact of counterfeits, and it's easy to see how undetected BOM surprises can tangle projects in a web of late-cycle delays, cost escalations and even redesigns.

Although nothing is completely risk-free, here are four practices designers can implement for additional insulation from component-related risks:

1. Put BOM Management on Par with Schematic and PCB Design Domains. The best, highest performance printed circuit board (PCB) design will be practically useless if suitably priced parts are unavailable to manufacture in volume. The BOM has traditionally been relegated to a late-cycle post-process, with characteristics that are typically viewed as someone else's responsibility, such as procurement or component engineering. Recognizing the BOM's importance as well as the significance of schematic and PCB design is an essential first step to mitigating the risks associated with electronic components selection and sourcing.

2. Improve The Designer's Situational Awareness. The term "situational awareness" is rooted in military and life-critical environments—where margins for error are tight and consequences of failure are extremely high. Getting the right information to designers early, in the right place and with negligible impact to their design activity, is paramount. The design environment is the place to inform the designer on electronic part dynamics such as counterfeit risk, availability or cost, where the information is most relevant and actionable.

3. Check Your BOM Status Early, Often and Throughout The Design Cycle. Electronic components are similar to airline tickets. The availability and price you see today may be different tomorrow. It is imperative for designers and down-cycle collaborators to monitor the status of their BOMs early and often. Although the use of Electrical Rules Checks (ERC) and Design Rule Checks (DRC) for schematic and PCB designs has long been a staple of electronic design automation tools, automated BOM checks are a relatively recent capability. Adding real-time BOM checks to the conventional ERC/DRC used throughout the design process and at manufacturing release time is a prudent step to identify and mitigate component related issues before they can affect manufacturing.

4. Establish Contingency Early for Risky Parts. There is more competition for the available global supply of parts, particularly widely used components. Although design organizations are familiar with the various "design for" initiatives including design for test and design for manufacturability, organizations may want to consider including the idea of designing for availability of components, or designing for component substitution as an initiative.

Consider contingency plans for critical design components. This will enable the substitution of the preferred manufacturer part number with the next highest ranked manufacturer part number choice. Establishing part choices early, or making them part of a centralized component library, can pay big dividends by building in dynamic response to changing component supplies.

Proactively Addressing Risks

Although some component-related risks are unavoidable, many can be overcome by augmenting design methodologies to move the visibility of component supply dynamics into the designer's workspace. Today's cloud component data and associated design environments, which enable real-time collaboration, provide a unique opportunity for organizations to reinvent the way they design and manufacture products.

Early risk identification through situational awareness is essential for overcoming the consequences associated with component supply problems. Improving design environments with these objectives can give a considerable competitive advantage to those who adopt these practices. DE

Vincent Mazur *is a Product & Persona Marketing Engineer at Altium (Altium.com). Prior to that, he co-founded a scientific electronic instrument business where he architected and designed handheld, battery-operated products using Altium Designer.*

NEWS, TRENDS & INSIGHTS

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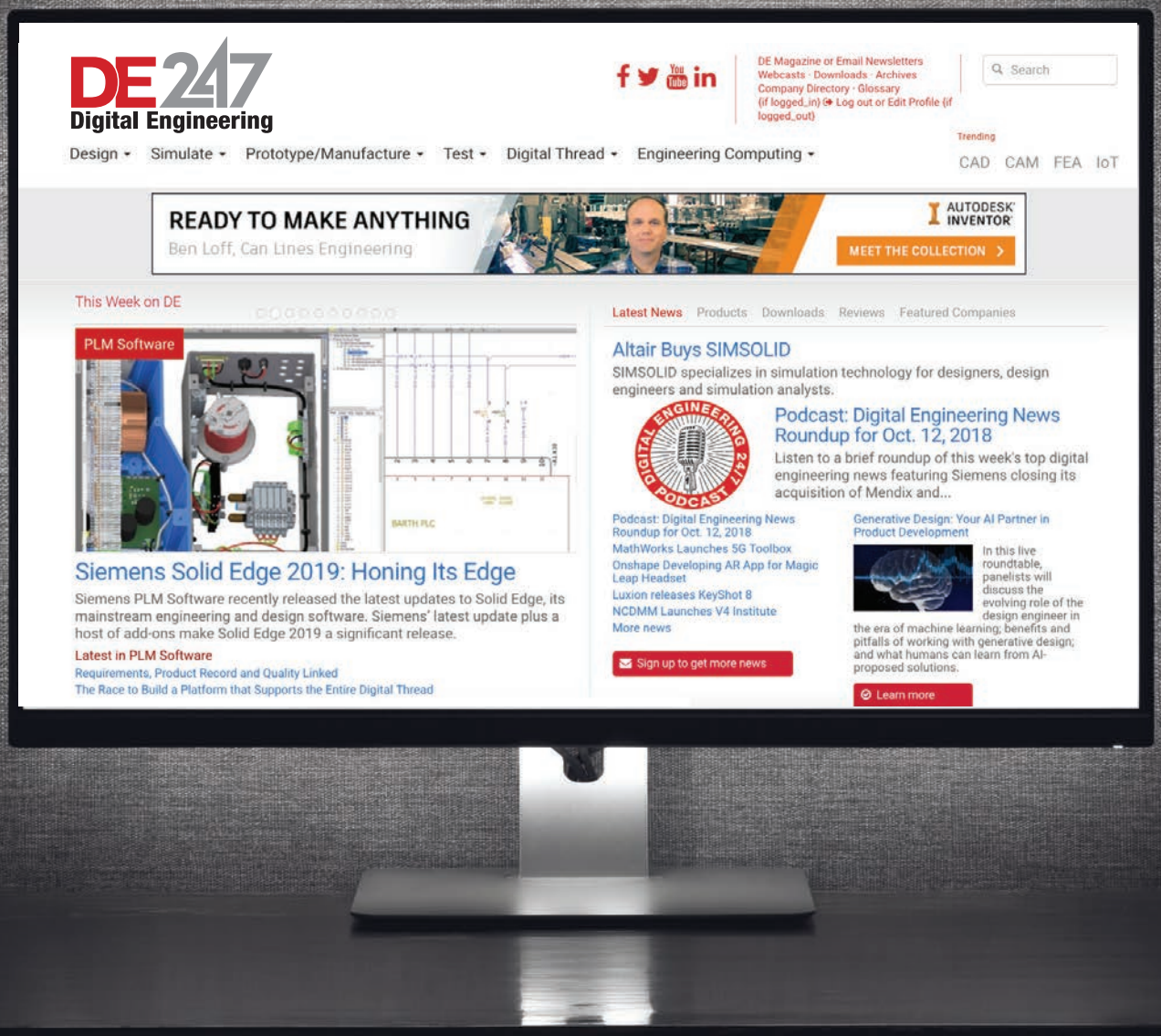

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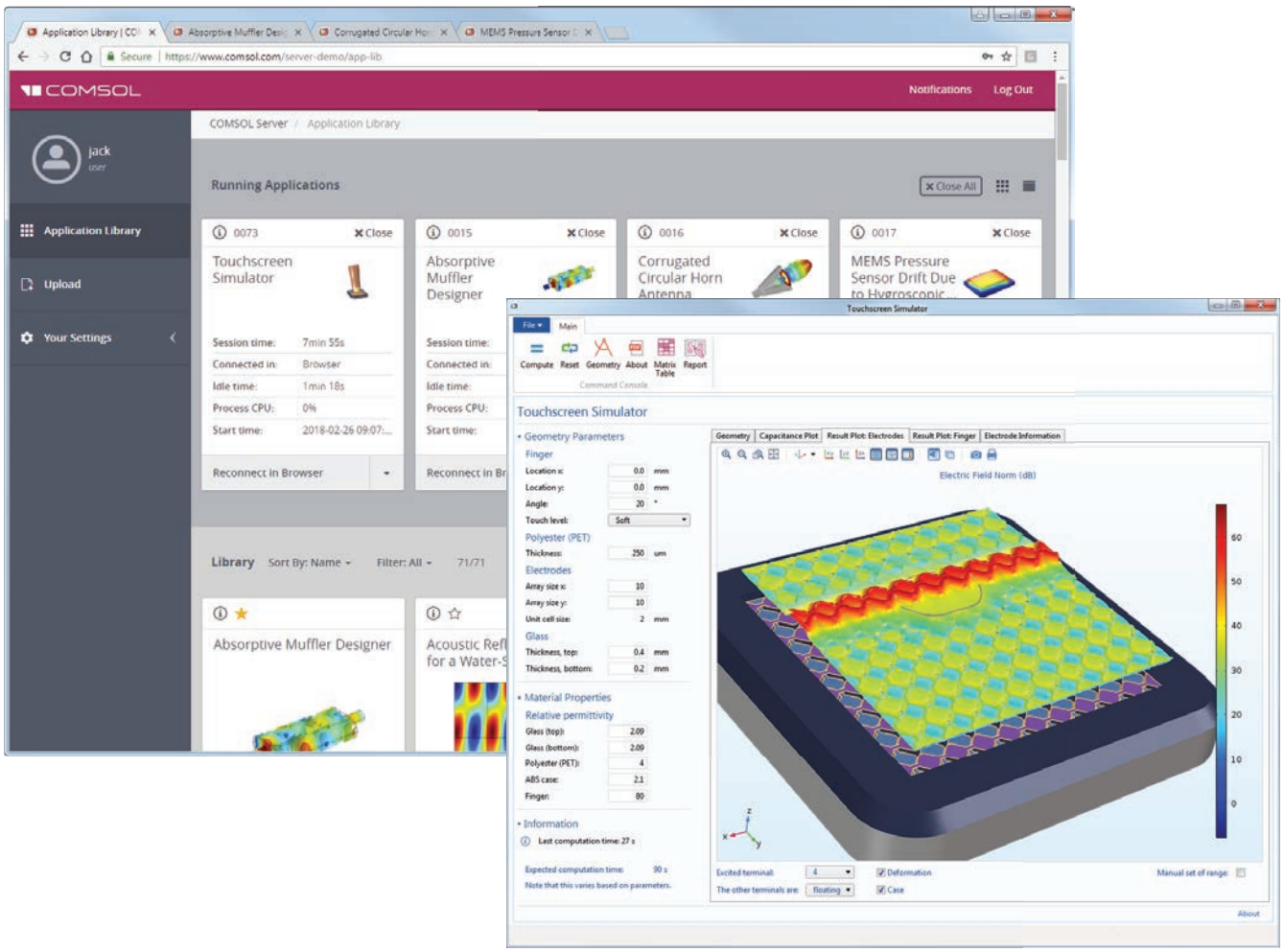
Develop better products — faster.



An example of a simulation application in the COMSOL Server™ application library. Application users can find an optimal capacitive touchscreen design without having any knowledge of the underlying mathematical model.

Industry engineers and researchers are accelerating product development by building numerical simulation applications and deploying them throughout their organizations. COMSOL Multiphysics® enables you to build specialized applications and COMSOL Server™ helps you distribute them to the right contributors at the right time in your product development workflow.

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